

Anterior Segment Parameters of Filipino-Americans Compared to Chinese-Americans and Caucasian Americans Using Anterior Segment Optical Coherence Tomography

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Purpose: We compare anterior segment characteristics of Filipino- versus Chinese- and Caucasian-Americans to describe the differences in risk factors among each ethnic group.

Methods: A cross-sectional study was conducted among Filipino, Chinese, and Caucasian subjects without glaucoma who underwent a standardized set of ocular examinations and anterior segment optical coherence tomography (Visante ASOCT) imaging. Zhongshan Angle Assessment Program (ZAAP) 4 was used for ASOCT image analysis. The following quantitative parameters were obtained from ZAAP: (1) angle opening distance (AOD500, AOD750), angle recess area at 750 μm (ARA), and trabecular-iris space area at 500 and 750 μm (TISA500, TISA750); (2) iris parameters, including iris thickness at 750 μm from the scleral spur (IT750), iris area (IArea), iris curvature or convexity (ICurv), and pupil diameter; (3) anterior chamber parameters; and (4) lens vault.

Results: The Filipino (122 eyes), Chinese (121 eyes), and Caucasian (111 eyes) subject groups were similar in terms of demographic and clinical characteristics. We reported pairwise comparisons of Filipino parameter values to Chinese or Caucasian values, represented as B-coefficients and *P* values. In multivariate analysis, Filipinos had narrower angles than Caucasians (AOD750, TISA 500, TISA 750, ARA, $P < 0.001$). Filipinos had thicker and more convex irises than Caucasians (IT750, IT 2000, ICurv $P < 0.003$). Angle and iris parameters were similar overall for Filipino and Chinese.

Conclusions: Filipinos appear to have more convex and thicker irises, smaller lens vault and narrower angles compared to Caucasians. Filipino eyes closely resembled Chinese eyes with similar iris and angle parameters.

Translational Relevance: The anatomic angle parameters of Filipinos may contribute to angle closure risk among this population, thus ASOCT and thorough angle analysis is recommended in this population.

Background

In the 2010 United States Census, Filipino Americans (population, 3.4 million) were noted to be the largest Southeast Asian population and the second largest Asian population in the United States.¹ The difference in population numbers compared to the largest group (Chinese) was only 400,000 (10% less). Those of Asian descent were found in the latest census to be the fastest growing group in percentage terms, and it is predicted that Filipino Americans will be the largest Asian group by the next census in 2020.

Despite the relatively large populations in the United States and the Philippines, relatively few studies exist in the peer-reviewed literature on this ethnic group in relation to glaucoma prevalence, subtype distribution, and risk assessment. Some studies exist regarding Filipinos and their relative glaucoma risk.²⁻⁶

Closed-angle glaucoma (CAG) is typically more aggressive than open-angle glaucoma (OAG). Although its worldwide prevalence is significantly less than that of OAG, it accounts for approximately half of the blindness attributable to glaucoma due to the estimated greater morbidity of this disease.^{7,8} Anatomic parameters, such as iris thickness, lens vault, and anterior chamber depth, may contribute to the development of CAG.^{3,9-12} These have been investigated mostly in the ethnic Chinese population. For example, previous studies showed that Chinese, compared to whites, have greater iris thickness and area, smaller anterior chamber depth and width, greater iris thickening from light-to-dark transition, and narrower angle parameters (angle opening distance and angle recess area).^{2-3,13-17} These anatomic features are consistent with the higher risk for angle closure disease in the Chinese population.

Although substantial data exist on the Chinese risk for angle closure, there is a gap in knowledge about these risk factors in the Filipino population and their relative risk for angle closure disease compared to other population groups.

The third national survey on blindness, conducted in the Philippines in 2002, ranked glaucoma as the third most common cause of bilateral blindness in the country.¹⁸ In a retrospective study conducted at a tertiary referral hospital in the Philippines, angle closure glaucoma (29.5%) was the most common type of glaucoma.¹⁹ However, anterior segment biometry has not been well-characterized in Filipinos, including in relation to other ethnicities.

We described and compared the anterior segment characteristics of Filipinos versus Chinese and Caucasians to better understand anatomic risk factors for angle closure spectrum diseases. We hypothesized that Filipinos (compared to whites) will have greater anatomic risk factors for angle closure, such as greater iris thickness and smaller anterior chamber width, similar to Chinese.

Materials and Methods

Study Design

A cross-sectional study was done of Filipino, Chinese, and Caucasian subjects without glaucoma. Caucasian and Chinese participants were recruited prospectively and consecutively from the comprehensive ophthalmology clinics at the University of California, San Francisco from May 2008 to May 2017. Filipino participants were recruited prospectively from a private ophthalmology clinic in Daly City from June to August 2017. Previous data from Caucasian and Chinese participants using similar standardized collection methods were used to compare to the Filipino data acquired for this study.

Inclusion criteria were age at least 40 years; self-reported Caucasian, Chinese, or Filipino ancestry of both parents; no evidence of glaucoma based on intraocular pressure (IOP) <21 mm Hg, absence of peripapillary retinal nerve fiber layer defects, and any optic nerve abnormalities consistent with glaucoma, and normal RNFL on OCT; and willingness and ability to participate in all study activities.

Exclusion criteria were a history of intraocular surgery, laser treatment, or ocular trauma; corneal or conjunctival abnormalities precluding adequate assessment of the anterior chamber by ASOCT imaging; active ocular infection; neuro-ophthalmologic disease; and diagnosis of glaucoma and/or use of any glaucoma medications. Any participants found with primary angle closure after enrollment were excluded because peripheral anterior synechiae can interfere with assessment of angle and/or iris parameters. The right eye was enrolled unless it did not meet inclusion and exclusion criteria, in which case the left eye was enrolled if all criteria were met.

This study was approved by the University of California, San Francisco (UCSF) Committee on Human Research. The study was done in accordance with the tenets of the Declaration of Helsinki. All participants provided written informed consent after explanation of the study and possible consequences.

Data Collection

Participants underwent a standardized set of ocular examinations, including slit-lamp examination, autorefractometry, ultrasound pachymetry, A-scan biometry (IOL Master, Carl Zeiss Meditec, Dublin, CA), and anterior segment optical coherence tomography (ASOCT; Visante OCT; Carl Zeiss Meditec) imaging.

ASOCT imaging was performed by a trained operator using a standardized protocol. Each ASOCT scan captured a 180° cross-sectional view of the nasal and temporal quadrants while the patient fixated at an internal fixation point within the ASOCT machine. Two scans were obtained: one with the illumination set at 379 to 390 lux, and another with lights turned off in which the illumination was below 1 lux as measured by the EasyView Digital Light Meter (model EA30; Extech Instruments, Inc., Waltham, MA). Patients were allowed 1 minute for dark adaptation before image acquisition. Scleral spur visibility, presence of central corneal reflection, continuity of anterior segment structures, and absence of motion artifacts were evaluated to select optimal images for analysis.

Custom software (Zhongshan Angle Assessment Program [ZAAP] 4, Guangzhou, China) was used for ASOCT image analysis. The ZAAP software uses predefined algorithms to calculate various anterior segment parameters after the operator identifies the scleral spurs on the ASOCT image.²⁰ The scleral spur was identified at the point where the curvature of the inner surface of the anterior chamber angle wall changes, which appears as an inward scleral protrusion.

Measurement of the following anatomic parameters were obtained from ZAAP analysis: (1) angle parameters, including angle opening distance at 500 and 750 μm from the scleral spur (AOD500, AOD750), angle recess area at 750 μm from the scleral spur (ARA), and trabecular-iris space area at 500 and 750 μm from the scleral spur (TISA500, TISA750); (2) iris parameters, including iris thickness at 750 μm from the scleral spur (IT750), iris area (IArea), iris curvature or convexity (ICurv), and pupil diameter; (3) anterior chamber parameters, including anterior chamber depth, width, area, and volume (ACD, ACW, ACA, ACV); and (4) lens vault. The ZAAP software quantifies nasal and temporal values of AOD500, AOD750, ARA, TISA500, TISA750, IT750, IArea, and ICurv; for these parameters, mean value was used for statistical analysis. A figure from the journal of current glaucoma practice shows the

different anterior chamber parameters measured with ASOCT.²¹

A single assessor performed all ZAAP analyses. Images in which the scleral spurs could not be identified were excluded from the final sample. Sixteen randomly selected ASOCT images from all subgroups were reanalyzed at a second time point by the same assessor, and the intraclass correlation coefficient (ICC) was calculated using a 1-way random-effects model to describe the reproducibility of measurements.

Autorefractometry (Automatic Refractor/Keratometer, Model KR-800S; Topcon Corp., Tokyo, Japan) was used to measure noncycloplegic refraction. Refractive status was represented by spherical equivalent (SE), defined as the sum of spherical error and half the cylindrical error. Axial length (AL) was measured by A-scan biometry (IOL Master Version 5.4.3, Carl Zeiss Meditec). Five sets of A-scan measurements were obtained, and mean AL was used for data analysis. Central corneal thickness was measured using an ultrasonic pachymeter (Corneo-Gauge Plus, Sonogage, Inc., Cleveland, OH).

Statistical Analyses

We characterized the sample by calculating summary percentages for categorical variables and mean and standard deviation (SD) for continuous variables. We assessed ethnic differences in continuous data using the 1-way analysis of variance (ANOVA) test and in categorical data using the χ^2 test. Anterior segment parameters were compared across ethnic subgroups using the Kruskal-Wallis test. Linear regression models allowed for pairwise comparisons after adjustment for age, sex, axial length, and pupillary diameter. $P < 0.05$ was considered statistically significant. The conservative Bonferroni correction for multiple comparisons was used when appropriate and $P < 0.003$ was considered statistically significant.

All data analyses were performed using STATA software (Stata/MP 13.0, College Station, TX). The data analyzed in this study were from nonilluminated conditions, other data acquired can be used in future prospective studies.

Results

We enrolled 125 eyes from Filipino, 125 from Chinese, and 118 from Caucasian subjects. Fourteen participants had unacceptable ASOCT images caus-

Table 1. Demographics and Clinical Characteristics of Each Ethnic Subgroup

	Filipino, <i>n</i> = 122	Chinese, <i>n</i> = 121	Caucasian, <i>n</i> = 111	<i>P</i> Value
Age	63.12 ± 14.95	59.98 ± 12.20	59.36 ± 11.77	0.061
Sex ^a				0.946 ^b
Male	60 (49.18%)	61 (50.41%)	57 (51.35%)	
Female	62 (50.82%)	60 (49.49%)	54 (48.65%)	
SE, diopters	−0.32 ± 2.25	−1.91 ± 3.67	−1.85 ± 3.13	<0.001
Central corneal thickness, μm	541.86 ± 28.55	547.58 ± 43.13	549.57 ± 32.32	0.239
Axial length, mm	23.95 ± 1.17	24.32 ± 1.52	24.26 ± 1.52	0.098
Pupillary diameter, mm	5.37 ± 1.47	4.57 ± 0.84	4.41 ± 1.03	<0.001

Data expressed as mean ± SD, *P* value was derived from 1-way ANOVA test.

^a Data expressed as *n* (%).

^b *P* value was derived from the χ^2 test.

ing poor angle visualization. These subjects were excluded, yielding a final sample of 122 Filipino, 121 Chinese, and 111 Caucasians.

Mean ages of the Filipino, Chinese, and Caucasian subgroups were 63 ± 15, 60 ± 12, and 59 ± 12 years, respectively. [Table 1](#) shows the demographic and clinical characteristics of each subgroup. The subgroups were similar in baseline characteristics, with some difference in SE and pupillary diameter (non-illuminated condition).

Mean anterior segment parameters comparing each ethnic subgroup showed statistical differences except for Iarea, Icurv, and lens vault ([Table 2](#)). [Table 3](#) reports pairwise comparisons of Filipinos parameter values to Chinese or Caucasian values, represented as B-coefficients and *P* values. In multivariate analysis, Filipinos had statistically significantly narrower angles than Caucasians (AOD750, TISA 500, TISA 750, ARA; *P* < 0.001). Filipinos had thicker and more convex irises than Caucasians (IT750, IT 2000,

Table 2. Comparison of Anterior Segment Parameters Between Ethnic Subgroups

	Filipino	Chinese	Caucasian	<i>P</i> Value
Angle parameters				
AOD 500, mm	0.29 ± 0.13	0.29 ± 0.16	0.35 ± 0.18	0.002 ^a
AOD 750, mm	0.37 ± 0.16	0.41 ± 0.23	0.49 ± 0.24	<0.001 ^b
TISA 500, mm ²	0.12 ± 0.05	0.12 ± 0.06	0.15 ± 0.08	<0.001 ^b
TISA 750, mm ²	0.21 ± 0.08	0.22 ± 0.11	0.17 ± 0.13	<0.001 ^b
ARA, mm ²	0.25 ± 0.11	0.26 ± 0.13	0.37 ± 0.18	<0.001 ^b
Iris parameters				
IT 750, mm	0.46 ± 0.09	0.46 ± 0.08	0.42 ± 0.09	<0.001 ^b
IT 2000, mm	0.48 ± 0.08	0.49 ± 0.08	0.42 ± 0.08	<0.001 ^b
ITCM, mm	0.62 ± 0.12	0.60 ± 0.08	0.58 ± 0.09	0.002 ^b
Iarea, mm ²	1.58 ± 0.30	1.61 ± 0.33	1.61 ± 0.36	0.96
Icurv, mm	0.31 ± 0.15	0.25 ± 0.15	0.24 ± 0.15	0.007 ^a
Anterior chamber parameters				
ACD, mm	2.72 ± 0.35	2.76 ± 0.39	2.96 ± 0.51	<0.001 ^b
ACW, mm	11.91 ± 0.45	12.00 ± 0.69	12.47 ± 1.42	<0.001 ^b
ACA, mm ²	21.34 ± 3.80	21.96 ± 4.43	24.87 ± 6.16	<0.001 ^b
ACV, mm ³	144.89 ± 32.22	142.59 ± 35.13	170.91 ± 44.37	<0.001 ^b
Lens vault, mm	301.71 ± 275.36	408.46 ± 312.62	402.48 ± 302.78	0.017 ^a

Data expressed as mean ± SD; *P* value was derived from Kruskal-Wallis test. ITCM, maximum central iris thickness.

^a Denotes *P* < 0.05.

^b Indicates statistically significant values with Bonferroni correction (*P* < 0.003).

Table 3. Differences in Anterior Segment Parameters in Filipinos Compared to Chinese and Caucasians

	Chinese			
	B Coefficient (SE)	P Value	Lower 95% CI	Upper 95% CI
Angle parameters				
AOD 500, mm	-0.0003 (0.019)	0.985	-0.038	0.037
AOD 750, mm	0.028 (0.025)	0.270	-0.022	0.077
TISA 500, mm ²	0.002 (0.007)	0.726	-0.011	0.016
TISA 750, mm ²	0.007 (0.013)	0.590	-0.018	0.032
ARA, mm ²	-0.0003 (0.016)	0.987	-0.032	0.031
Iris parameters				
IT 750, mm	-0.003 (0.010)	0.789	-0.023	0.018
IT 2000, mm ²	0.009 (0.010)	0.360	-0.011	0.029
ITCM, mm	-0.014 (0.013)	0.287	-0.041	0.012
larea, mm ²	0.018 (0.038)	0.646	-0.058	0.093
lcurv, mm	-0.048 (0.019)	0.012 ^a	-0.085	-0.011
Anterior chamber parameters				
ACD, mm	0.002 (0.045)	0.962	-0.088	0.092
ACW, mm	0.064 (0.074)	0.391	-0.082	0.209
ACA, mm ²	0.226 (0.493)	0.647	-0.745	1.197
ACV, mm ³	-4.593 (4.102)	0.264	-12.676	3.489
Lens vault, mm	138.529 (37.718)	<0.001 ^b	68.148	208.910

General linear model adjusted for age, sex, axial length, and pupillary diameter. CI, confidence interval.

^a Denotes $P < 0.05$.

^b Indicates statistically significant values with Bonferroni correction ($P < 0.003$).

Table 3. Extended

	Caucasian			
	B Coefficient (SE)	P Value	Lower 95% CI	Upper 95% CI
Angle parameters				
AOD 500, mm	0.062 (0.021)	0.004 ^a	0.020	0.103
AOD 750, mm	0.109 (0.027)	<0.001 ^b	0.056	0.162
TISA 500, mm ²	0.032 (0.009)	<0.001 ^b	0.015	0.049
TISA 750, mm ²	0.056 (0.014)	<0.001 ^b	0.028	0.084
ARA, mm ²	0.117 (0.020)	<0.001 ^b	0.077	0.156
Iris parameters				
IT 750, mm	-0.036 (0.011)	0.002 ^b	-0.060	-0.013
IT 2000, mm ²	-0.053 (0.010)	<0.001 ^b	-0.073	0.033
ITCM, mm	-0.038 (0.015)	0.011 ^a	-0.067	-0.009
larea, mm ²	0.029 (0.043)	0.496	-0.055	0.114
lcurv, mm	-0.063 (0.019)	0.001 ^b	-0.100	-0.026
Anterior chamber parameters				
ACD, mm	0.231 (0.058)	<0.001 ^b	0.117	0.346
ACW, mm	0.711 (0.131)	<0.001 ^b	0.453	0.970
ACA, mm ²	3.678 (0.647)	<0.001 ^b	2.403	4.953
ACV, mm ³	26.930 (4.916)	<0.001 ^b	17.242	36.618
Lens vault, mm	148.735 (37.602)	<0.001 ^b	74.146	222.855

Icurv; $P < 0.003$). Angle and iris parameters were overall similar between Filipino and Chinese subjects.

Filipinos had smaller anterior chambers than Caucasians as measured by ACD, ACW, ACA, and ACV ($P < 0.001$). No significant differences existed between Chinese and Filipino anterior chamber parameters. Filipino lens vault was significantly smaller compared to Chinese and Caucasians ($P < 0.001$ for both).

Discussion

We assessed anterior segment biometric parameters of nonglaucomatous eyes of ethnic Filipinos and compared them to those from Chinese and Caucasian eyes. Filipinos appeared to have more convex and thicker irises, narrower angles, and smaller lens vault compared to Caucasians. Overall, the anterior segments of Filipino eyes closely resembled those of Chinese eyes with similar iris and angle parameters.

In our study, Filipino eyes had narrow angles resembling the Chinese, suggesting that these ethnicities may be anatomically predisposed to angle narrowing and closure. The angle parameters describe the area of spatial access to the trabecular meshwork where aqueous filtration occurs. Among them, the most sensitive for detection of impaired access to the trabecular meshwork is likely TISA, which represents the filtration area within the angle recess area. In a study of nearly 500 patients, Chinese had smaller TISA and ARA than Caucasians.¹⁴ The angle parameters of Filipinos in our study suggested that there is higher risk in this group for angle closure compared to Caucasians. The study angle results were consistent with those of previous reports revealing a higher prevalence of narrow angles in Filipino-Americans (24%) than in Caucasian-Americans (3.8%).^{3,4}

In our study, Filipinos had thicker irises than Caucasians, similar to the existing literature on Chinese subjects.^{2,16} Some investigators hypothesize that increased iris pigment in darker-colored irises may account for ethnic differences in iris thickness.² Previous reports by Wang et al.¹² discussed that a thicker iris might lead to angle closure because the iris would be in closer proximity to the angle resulting to angle crowding. The irises of Filipinos also were more convex (anteriorly bowed) compared to Chinese and Caucasians. Increased iris curvature can predispose to angle closure by a predominantly pupillary block-like mechanism.^{9,11-12}

In our study, Filipino lens vault was significantly smaller compared to that in Chinese and Caucasians.

It is the perpendicular distance from the anterior pole of the lens and the horizontal line joining the two scleral spurs. In a study involving Chinese eyes, lens vault was an independent anatomic parameter associated with angle closure.²² Prior studies involving Filipino patients suggest a high prevalence of angle closure in this population;^{4,19} our lens vault result is consistent with what is expected as an association with narrow angles.

The similarity between Filipinos and Chinese maybe attributed to the ancestry variety of Filipinos, which comprises Malay, Indonesian, Chinese, and Spanish descent. In our study, no specific determination of ethnicities was conducted and it is suggested that this should be included in future studies to have a clearer anatomic picture of Filipino eyes.

Our study has several limitations. First, since this study was clinic-based, our findings may not be generalizable to the entire population of Filipinos in the United States or the Philippines. Second, ASOCT images of only horizontal quadrants were collected due to difficulty in vertical limbal exposure; however, it may have less impact on the assessment of the associated parameters analyzed. Only the images captured in the dark were used in this study, so inferences cannot be made on iris dynamics under other lighting conditions. Manual scleral spur localization is subjective in nature. However, to control this factor a single ophthalmologist was assigned to read all images. Finally, patient recruitment occurred at two sites: Chinese and Caucasian participants from ophthalmology clinics at an academic medical center and Filipino participants from a private ophthalmology clinic. We endeavored to minimize bias by strict standardization of data collection and analysis. The same ASOCT device and scanning protocols were used at both sites.

We described the anterior segment characteristics of ethnic Filipinos. Our results suggested that Filipinos, similar to the Chinese, have narrower angles and thicker, more convex irises compared to Caucasians. These iris characteristics predict and are anatomically related to angle narrowing, independent of axial length.^{11,12} In addition, Filipino lens vault was smaller compared to Caucasian and Chinese lens vaults. Together, these anatomic characteristics may contribute to angle closure risk among the Filipinos.

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