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Optic Disk Size Variability Between African, Asian, Caucasian, Hispanic and Filipino Americans Using Heidelberg Retinal Tomography

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Abstract

Purpose—To compare the optic disk size of African, Asian, Caucasian, Hispanic and Filipino American patients in a multiethnic glaucoma practice.

Patients and Methods—576 eyes of 319 patients who had consecutively received Heidelberg Retinal Tomography II (HRT) from February 2006 to October 2007 in a glaucoma clinic that met inclusion criteria were included. The five ethnic groups represented were Caucasian (n = 215, 37.3%), Asian (non-Filipino) (n = 178, 30.8%), African (n = 67, 11.6%), Hispanic (n = 66, 11.4%) and Filipino American (n= 50, 8.7%). The relationships of optic disk size (Global Disc Area) with race, age, gender, diagnosis, central corneal thickness (CCT), spherical equivalent refraction (SE), and cylindrical refraction were evaluated using multivariate regression analysis adjusting for confounders.

Results—Mean optic disk size of Caucasian-Americans (2.15 mm^2) was significantly smaller than that of African (2.55 mm^2), Asian (2.38 mm^2), Filipino (2.48 mm^2), and Hispanic Americans (2.57 mm^2) (all, $P \leq 0.0007$). Global Disk Area was not statistically different between all other races (all, $P \geq 0.054$). Global Disk Area increased with SE (P=0.013), but was found to not vary by age, gender, diagnosis, CCT, or cylindrical refraction (all, $P \geq 0.08$).

Conclusions—In our glaucoma clinic-based population, Caucasian-Americans had smaller optic disks than all other races, and there were no optic disk size differences among the other races studied. Optic disk size had no significant relationship to age, gender, CCT, cylindrical refraction or diagnosis, and a small direct relationship to SE. Confirmation of these results in a population-based study is needed.

Introduction

Optic disk size has been investigated extensively and may be important in evaluating an optic nerve for glaucomatous injury. The cup-to-disk ratio is used as a key parameter in distinguishing normal from glaucomatous nerves, but data suggests this ratio may vary significantly by the size of the optic disk.[1-5] It has been suggested that normal eyes with large optic disks may have large physiologic cup-to-disk ratios[6], while “small” cup-to-disk ratios in small optic disks may be consistent with glaucomatous injury[7].

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Racial variation in optic disk size has been reported. One study, which used fundus photography to compare optic disk size between African-Americans, Asian- Americans, Caucasian-Americans, Hispanic-Americans, and Indian-Americans (of the Indian subcontinent), found that Caucasian-Americans and Hispanic-Americans had significantly smaller optic disk sizes than the other races studied.[8] Other studies have evaluated races in isolation9, or have compared Caucasians to those of African descent10¯12. A careful computerized review of the literature utilizing PubMed revealed little data on how optic disk size varied between multiple races using modern imaging devices such as scanning laser ophthalmoscopy. In addition, almost no information was found describing the optic disk size of Filipino-Americans, who constitute one of the largest Asian-American subgroups.[13]

We have therefore conducted a retrospective, cross-sectional analysis to compare optic disk size by race using scanning laser ophthalmoscopy in an ethnically diverse population of patients including African-Americans, Asian-Americans (non-Filipino), Caucasian-Americans, Filipino-Americans and Hispanic-Americans. In addition, we assessed the relationship between optic disk size and age, gender, diagnosis, central corneal thickness (CCT), and refractive error.

Methods

Data Collection

Study approval by the University of California, San Francisco Committee on Human Research was granted before data collection commenced. Data from 703 eyes (356 right, 357 left) from 372 patients from a tertiary-care glaucoma clinic (SL) who had consecutively received confocal scanning laser ophthalmoscopy (Heidelberg Retina Tomograph, HRT 2; Heidelberg Engineering, Dossenheim, Germany) by the same device from February 2006 to October 2007 was retrospectively reviewed. All glaucoma and suspect patients within this clinic are routinely scanned annually with the HRT 2, with rare exceptions including patients under 10 years of age and those who refuse.

Clinical patient data was also collected on patient age, gender, race (self-designated), history of intraocular surgery (e.g., laser peripheral iridotomy, cataract extraction with intraocular lens placement, trabeculectomy), refraction (SE and cylindrical refraction), and central corneal thickness (CCT). In the case that a study patient had multiple HRT 2 scans on file, the most recent scan during the study period was used. All clinical patient data aside from CCT was gathered from the clinic visit record from the date of the HRT 2 scan included for analysis or, if the patient was not seen that day, on the date of their next clinic visit. CCT data was collected from the most recent clinic visit record in which it was recorded.

Before HRT 2 data collection commenced, each HRT 2 scan included for analysis was reviewed by a glaucoma specialist (SL) to confirm the accuracy of the optic disk contour line. The line was found to be inaccurate in seven eyes and was redrawn by the glaucoma specialist.

A minority of patients who had received HRT 2 during the study period did not have data concerning their race available for review. These patients were removed from analysis, twenty five in all. In addition, two patients were self-designated Indian-American, and one Native American. These patients were not considered to fit into the race categories of the study and were also excluded. Twenty eight right and twenty eight left eyes were excluded based on these two criteria.

Eyes were further excluded if they had any history of intraocular surgery besides laser peripheral iridotomy, selective laser trabeculoplasty, cataract extraction with intraocular lens placement, or trabeculectomy. Excluded eyes had undergone surgery such as vitrectomy, retinal detachment repair or ruptured globe repair that was considered to have the potential to affect optic nerve imaging with HRT. Eleven right eyes and sixteen left eyes were excluded based on these criteria.

Eyes were then excluded if the Standard Deviation of their HRT 2 data was 40 microns or more. Twenty three right eyes and thirty one left eyes were excluded based on this criterion.

After all exclusion criteria were met, 294 right eyes and 282 left eyes remained for analysis. Of these patients, CCT data was unavailable in 85 eyes.

Definitions

Eyes defined as primary open angle glaucoma (POAG), pseudo-exfoliative glaucoma (PXG), chronic angle-closure glaucoma (CACG), mixed-mechanism glaucoma (MMG), and pigmentary glaucoma demonstrated visual field (VF) and/or optic nerve changes consistent with glaucoma as well as a history of an intraocular pressure (IOP) recording of >21 mmHg by Goldmann applanation tonometry. Eyes with POAG, PXG, and pigmentary glaucoma had gonioscopically open angles. Patients with CACG demonstrated closure of the angle with apposition of the peripheral iris to the trabecular meshwork for at least 3 clock hours. Those with MMG demonstrated a history of gonioscopically occludable angles, and a history of glaucoma progression after their angles had become gonioscopically open following laser peripheral iridotomy. NTG patients were defined as demonstrating VF and optic nerve changes consistent with glaucoma, a history of IOP measurements that did not exceed 21 mmHg, and open angles on gonioscopy. Eyes with the diagnosis of traumatic glaucoma demonstrated a history of blunt trauma (no study patient experienced penetrating trauma) resulting in at least one IOP recording >21 mmHg, and VF and/or optic nerve changes consistent with glaucoma. Glaucoma suspects were patients with optic nerve appearance suggestive of glaucoma without typical VF changes or a history of IOP recordings >21 mmHg, and with open angles on gonioscopy. Ocular hypertension was assigned in patients with IOP >21 mmHg, normal-appearing optic nerves and VFs, and open angles on gonioscopy. “Glaucomatous eyes” were defined as those with the diagnosis of POAG, CACG, NTG, PXG, pigmentary glaucoma, and traumatic glaucoma.

Statistical Analysis

Both right and left eyes were included for analysis. To avoid statistical dependence of observations made on the two eyes of a given patient, linear mixed models were used[14], clustering by patient, to determine the regression coefficients for each predictor (such as race, diagnosis, age, gender, CCT, SE, and cylindrical refraction) on the outcome variables of interest. Significance tests of individual predictors were performed using the likelihood-ratio chi-square, based on maximum likelihood estimation.

To determine whether age was associated with race in our study sample, we used the Kruskal-Wallis test. The association between gender and race in our study sample, in addition to the differences in race, gender, and diagnosis between the groups with and without CCT data, was assessed using the multidimensional Fisher Exact Test[15]. When evaluating the effect of race on refractive error (SE) in multivariate analysis, cylindrical refraction was omitted from our model due to its involvement with the calculation of SE. SE was similarly omitted from our model when evaluating the effect of race on cylindrical refraction.

All statistical tests were conducted using the R statistical package (v. 2.6.0 for Macintosh, http://www.r-project.org).

Significance *P*-values less than 0.05 were considered statistically significant.

Results

Description of Study Population

A total of 576 eyes (294 right, 282 left) from 319 patients were included in the study. The demographic and clinical characteristics of the study population are provided in Tables 1 and 2. In all tables and text, race is listed alphabetically. Unless otherwise noted, tables and text include combined results from both right and left eyes.

The Asian-American population was comprised of 82 Chinese eyes, 20 Korean eyes, 16 Japanese eyes, 13 Vietnamese eyes, and 7 other Asian-American (3 Burmese, 2 Indonesian and 2 Cambodian) and 38 unclassified Asian-American.

A significant difference was found in the gender distribution of eyes between the races in the study population (P=0.005, Fisher Exact Test) with less female eyes in the Caucasian-American group compared to the Hispanic-American and Filipino-American groups. Age was not found to vary by race in our population (P=0.15, Kruskal-Wallis test).

Individuals with missing CCT data were also compared to those with complete CCT data. The mean age of individuals with missing CCT data was 68.4 years, and those with complete CCT data was 64.2 years (P=0.034, Student's T test). The fraction of individuals with missing CCT data differed by race (P=0.039, Fisher Exact Test), with a maximum of 31% missing CCT data in the Filipino-American population, and a minimum of 8% missing CCT data in the African-American population. The groups with and without CCT data also differed in terms of diagnosis (P=0.0001, Fisher Exact Test), with less eyes diagnosed with ocular hypertension, mixed-mechanism glaucoma, and pigmentary glaucoma in the group missing CCT. No differences were found in gender between the groups with and without CCT data (P>0.99, Fisher Exact Test).

Data Analysis

The mean Global Disk Area for all eyes was 2.34 ± 0.59 mm^2, with a range of 0.71 mm^2 to 4.44 mm^2. Table 3 represents the mean Global Disk Area by race. Within each race, there was no significant difference in Global Disk Area between right and left eyes (all, P≥0.13). There was no significant difference between the mean Global Disk Area of glaucomatous eyes (defined above) (2.34 mm^2 ± 0.58 mm^2) and non-glaucomatous eyes (defined above) (2.35 mm^2 ± 0.60 mm^2) (P=0.91).

In the multivariate model (described above), race was a significant predictor of Global Disk Area (P<0.0001, likelihood ratio test). Caucasian-American eyes had significantly less Global Disk Area than all other racial groups (all, P≤0.0007). Global Disk Area was not statistically different between all other races (all, P≥0.054). The finding that Global Disc Area in Filipino-American eyes tended to larger than that in Asian-American eyes approached statistical significance (P=0.054), but all other comparisons of Global Disc Area between races did not (all, P≥0.22).

In multivariate analysis, there was a significant positive relationship between SE and Global Disk Area, with Global Disk Area increasing 0.028 mm^2 in our population for each additional positive diopter of SE (P=0.013, likelihood ratio test). Global Disk Area was found to not vary by age, gender, CCT or cylindrical refraction when correcting for all other parameters in our model (all, P≥0.11, likelihood ratio test). In addition, Global Disk Area did not vary by CCT when considering only eyes diagnosed with POAG (P=0.28, likelihood ratio test). Global Disc Area did not vary by diagnosis in multivariate analysis (P=0.08, likelihood ratio test).

In multivariate analysis, Global Rim Area did not vary by race (P = 0.072, likelihood ratio test). In univariate analysis, Caucasian-American eyes had a significant difference in average Global Rim Area between glaucoma suspect eyes and glaucomatous (as defined above) eyes (0.152 mm^2, P=0.012), and all other races did not (P≥0.26). Average Global Rim Area in glaucoma suspect and glaucomatous eyes are displayed by race in Table 4.

Average refractive error (SE), CCT and cylindrical refraction are displayed by race in Table 5. In multivariate analysis, there was no difference found by race in refractive error (P=0.27, likelihood ratio test) or cylindrical refraction (P=0.21, likelihood ratio test). However, racial variation of CCT was found (P=0.004, likelihood ratio test). Caucasian-American eyes had significantly larger CCT than all other races (all, P≤0.048), but no other significant differences in CCT by race were found (all, P≥0.16). CCT was not found to vary by age in our model (P=0.58).

Discussion

Several studies comparing optic nerve size between races have been published. One study suggested that Caucasian-Americans tend to have smaller optic disks, as measured by video-ophthalmography, than those of African-Americans.[10] Another provides fundus photography data suggesting that Caucasian-American and Hispanic-American optic disks are smaller than those of Indian-Americans (of the Indian subcontinent), African-Americans, and Asian-Americans.[8] Other studies have used HRT to confirm that optic disk sizes tend to be smaller in Caucasian-Americans than in African-Americans.[11, 12, 16-18] One Chinese study used fundus photography to determine that mean optic disk size in Mainland Chinese may be larger than what has been published about Caucasian-American optic disk size.[19]

Our findings suggest that optic disk area is, on average and within the context of our clinic-based population, significantly smaller in Caucasian-American eyes than the eyes of all other racial groups studied. In addition, no other significant differences were found in optic disk size between any of the other races studied. These findings are significant when correcting for age, gender, refractive error (SE and cylindrical refraction), CCT and diagnosis in a multivariate model.

It is unclear why our results suggest that Hispanic-American optic disk size is larger than what has been published previously.[8] Much of the difference may be explained by the inherent heterogeneity of the Hispanic-American population. The discrepancy may also be a result of the contradictory study using a different imaging method (fundus photography), a different statistic (no correction for age or CCT in multivariate analysis), less eyes (twenty four), and a different population (normal volunteers) than the present study.[8]

Studies from several populations have suggested that individuals with larger optic disks tend to have a higher prevalence of glaucoma.[20-22] One such population is African-Americans, who tend to have both a larger optic disk size than Caucasians[12, 16, 23] and a higher incidence of glaucoma[24, 25]. Observations such as these have prompted the hypothesis that individuals with large optic disks may have an increased susceptibility to glaucoma.[26] Other studies, however, suggest no such relationship between optic disk size and glaucoma prevalence[27, 28] and therefore no link between optic disk size and glaucoma susceptibility. Indeed, some authors have suggested that the correlation between larger optic disk size and increased prevalence of glaucoma found in many studies may be explained by factors other than a causal relationship[1].

The present study has a limited ability to address the relationship between optic disk size and glaucoma susceptibility. The retrospective study design does not allow us to evaluate the relative risk for an individual with a large optic disk for developing glaucoma. Also, our patients represent a referral population to a tertiary-care glaucoma clinic and thus may not reflect a normal population. Furthermore, our study included a limited amount of normal eyes, which does not permit reliable comparison between the mean optic disk size of normal and glaucomatous eyes in our population. With these limitations, our study found no significant difference in optic disk size between glaucomatous and non-glaucomatous eyes in univariate analysis. Our major findings that African-Americans may not be the only group with larger optic disks than Caucasian-Americans is supported by previous evidence.[8, 19] It may be that larger disc size among other ethnic groups puts them at increased risk for glaucoma development. A large, prospective, population-based study would be better suited to evaluate the potential link between optic disk size and risk of developing glaucoma

It has long been known that cup-to-disk ratio varies directly with optic disk size.[1-5] This relationship suggests that the clinical consideration of optic disk size is important when evaluating for glaucomatous injury. Often, many clinicians rely on the clinically apparent vertical cup-to-disk length ratio when evaluating the appearance of an optic nerve without formally considering optic nerve size, at least in part because of the inherent difficulty in accurately measuring optic disk size at the slit-lamp.

Our results suggest that optic disk size may vary by race, implying that our reliance on clinical cup-to-disk ratio may be of particular importance ethnically. Caucasian-Americans in our population, because of their smaller disk sizes, are likely to manifest smaller cup-to-disk ratios for a given amount of neuroretinal rim area than other races. Simple geometrical analysis of our data on Global Disk Area can be used to illustrate this point. For eyes with a 0.5 linear cup-to-disk ratio, a Caucasian-American eye in our population will have an average of 10% less neuroretinal rim area than an Asian-American eye, 13% less than a Filipino-American eye, 14% less than an African-American eye, and 16% less than a Hispanic-American eye in our population, with this disparity increasing quadratically with increasing linear cup-to-disk ratio.

This problem of scale may have the potential to result in the tendency for clinicians to diagnose Caucasian-Americans with glaucoma after more neuroretinal rim has been lost than they might in other groups. In our population, Caucasian-Americans were the only race to have a statistical difference in Global Rim Area between eyes diagnosed with glaucoma and glaucoma suspicion. This may be an indication that, in our population, Caucasian-Americans were indeed diagnosed later than individuals in the other racial groups.

There is controversy regarding the effects of refraction on optic disk size. Several studies using various imaging modalities have suggested that optic disk size varies proportionately with refractive error[19, 29-32], while others suggest no such relationship[8, 9, 12, 33-35]. In multivariate analysis of our data, SE was found to be a predictor of Global Disk Area. The two variables had a positive, although small relationship. Some studies have suggested that CCT may vary with optic disk size in all eyes or those with POAG[29, 36] while other, larger studies evaluating CCT and optic disk size have suggested no relationship[31, 37]. Our multivariate analysis revealed no relationship between CCT and Global Disk Area in our population when correcting for diagnosis, or in the POAG group alone. Published data is in disagreement about the effects of gender on optic disk size with several studies suggesting women have smaller optic disks than men[8, 12, 35], and others showing no difference[9, 19, 29, 32-34]. Our results in multivariate analysis reveal no relationship between gender and optic disk size in our population. Other studies have suggested that optic disk size may be related to age[29, 32], while many others have not[9, 12, 19, 34, 35]. Our model shows no relationship between age and optic disk size in our population. Our model revealed optic disk size to not vary by diagnosis in our population, although several studies have suggested that optic disk size may be smaller in patients with POAG[22, 36, 38], In addition, our multivariate analysis provides no evidence that optic disk size varies significantly by cylindrical error in our population.

The value of our study lies in its comparison of eyes between a diverse grouping of different ethnic populations from the same clinic, scanned by the same HRT 2 device, and with each scan reviewed by the same glaucoma specialist. In addition, the study adjusted for a large amount of potential confounders including age, gender, diagnosis, SE, CCT, and cylindrical refraction. This approach promotes an improved understanding of the isolated relationship of race to the other parameters studied.

There are some limitations to our study. All study patients were recruited from a tertiary care glaucoma clinic, which creates a risk of referral and sampling bias. Glaucoma specialists are often referred patients with larger optic disks as they tend to manifest larger cup-to-disk ratios, which may skew our population. It seems unlikely, however, that this effect is race-dependent and therefore prone to affect our comparisons of optic disk size between racial groups. An analysis similar to the one performed in this study but using normal subjects is needed to confirm our results.

Another limitation of this study is that by dividing eyes from our population into different diagnostic groups, several diagnostic groups were created that had a small number of eyes. Our study therefore has insufficient power to reliably compare the mean optic disk size between eyes of all of the specific diagnoses represented in this study. The results of such an analysis however might help illuminate the potential link between optic disk size and the risk of developing glaucoma. A larger, population-based, prospective study would be better suited for this evaluation.

This study also suffers from a weakness that affects any study of race, namely its inherent assumption that results derived from the ethnically divided study populations may somehow be generalized to some larger populations or “races” in general. This is problematic for several reasons, including its assumption of relative genetic homogeneity within certain racial populations, and its assumption that individuals from these populations may be easily identified by self-report or otherwise. This is surely not the case, and the ethnic groupings used in this study, although often present in ophthalmic literature, are certainly difficult to define and therefore imprecise.

In conclusion, the results of our study add to the evidence that racial variation in optic disk size indeed exists. In our clinic-based population, Caucasian-Americans tended to have smaller optic disks that those of all other racial groups studied, and no significant difference was found in optic disk size between any other racial groups. Also, optic disk size was not found to vary significantly with age, gender, CCT, cylindrical refraction or diagnosis, but did show a small direct relationship to SE in our population. Further population-based investigation is needed to confirm these results.

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Table 1

Characteristics of Study Population

	Total (%)	Af-Am (%)	As-Am (%)	Ca-Am (%)	Fi-Am (%)	Hi-Am (%)
Number of Eyes	576 (100)	67 (100)	179 (100)	215 (100)	50 (100)	65 (100)
OD	294 (51)	34 (50.7)	93 (52)	107 (49.8)	25 (50)	35 (53.8)
OS	282 (49)	33 (49.3)	86 (48)	108 (50.2)	25 (50)	30 (46.2)
Gender						
Male	206 (35.7)	24 (35.8)	60 (33.5)	99 (46)	10 (20)	12(18.5)
Female	370 (64.3)	43 (64.2)	119 (66.5)	116 (54)	40 (80)	53 (81.5)
Age						
<30	7 (1.2)	0 (0)	4 (2.2)	0 (0)	0 (0)	3 (4.6)
30-39	14 (2.4)	2 (3)	0 (0)	10 (4.7)	2 (4)	0 (0)
40-49	49 (8.5)	10 (14.9)	16 (8.9)	14 (6.5)	2 (4)	7 (10.8)
50-59	97 (16.8)	15 (22.4)	29 (16.2)	36 (16.7)	10 (20)	7 (10.8)
60-69	203 (35.2)	20 (30)	61 (34.1)	90 (41.9)	20 (40)	12 (18.5)
70-79	151 (26.2)	17 (25.4)	48 (26.8)	52 (24.2)	11 (22)	23 (35.4)
≥80	55 (9.5)	3 (4.5)	21 (11.7)	13 (6)	5 (10)	13 (20)
Diagnosis						
POAG	160 (27.7)	28 (41.8)	35 (19.6)	66 (30.7)	9 (18)	22 (33.8)
CACG	14 (2.4)	1 (1.5)	7 (3.9)	6 (2.8)	0 (0)	0 (0)
MMG	25 (4.3)	3 (4.5)	9 (5)	7 (3.3)	2 (4)	4 (6.2)
NTG	19 (3.3)	1 (1.5)	10 (5.6)	3 (1.4)	2 (4)	3 (4.6)
PXG	19 (3.3)	0 (0)	1 (0.6)	16 (7.4)	0 (0)	2 (3.1)
Pigmentary Glaucoma	4 (0.7)	0 (0)	0 (0)	4 (1.9)	0 (0)	0 (0)
Traumatic Glaucoma	1 (0.2)	0 (0)	0 (0)	1 (0.5)	0 (0)	0 (0)
GS	277 (48.0)	31 (46.3)	91 (50.8)	91 (42.3)	35 (70)	29 (44.6)
OHTN	21 (3.6)	0 (0)	7 (3.9)	14 (6.5)	0 (0)	0 (0)
Normal	6 (1.0)	0 (0)	4 (2.2)	1 (0.5)	0 (0)	1 (1.5)
Narrow Angles	26 (4.5)	2 (3)	14 (7.8)	4 (1.9)	2 (4)	4 (6.2)
Posner Schlossman	1 (0.2)	0 (0)	1 (0.6)	0 (0)	0 (0)	0 (0)
PXE	2 (0.3)	0 (0)	0 (0)	2 (0.9)	0 (0)	0 (0)
ERM	1 (0.2)	1 (1.5)	0 (0)	0 (0)	0 (0)	0 (0)

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Af-Am = African-American; As-Am = Asian-American; Ca-Am = Caucasian-American; Fi-Am = Filipino-American; Hi- Am = Hispanic-American POAG = primary open-angle glaucoma; CACG = chronic angle-closure glaucoma; MMG = mixed-mechanism glaucoma; NTG = normotension glaucoma; PXG = pseudo-exfoliative glaucoma; GS = glaucoma suspect; OHTN = ocular hypertension; PXE = pseudo-exfoliation syndrome (no glaucoma); ERM = epi-retinal membrane; SD = standard deviation.

Table 2

Mean Age by Race

Population	Mean Age (yrs) ± Standard Deviation
All Eyes	64.4 ± 12.9
African-American	59.2 ± 13.7
Asian-American	61.5 ± 13.5
Caucasian-American	67.9 ± 12.2
Filipino-American	62.1 ± 12.1
Hispanic-American	67.7 ± 8.8

Table 3

Global Disk Area by Race

Population	Mean Global Disk Area (all eyes) (mm^2) ± SD	Mean Global Disk Area (OD only) (mm^2) ± SD	Mean Global Disk Area (OS only) (mm^2) ± SD
African-American	2.55 ± 0.51	2.55 ± 0.51	2.54 ± 0.52
Asian-American	2.38 ± 0.54	2.44 ± 0.51	2.32 ± 0.56
Caucasian-American	2.15 ± 0.58	2.11 ±0.58	2.19 ± 0.59
Filipino-American	2.48 ± 0.70	2.63 ± 0.78	2.32 ± 0.58
Hispanic-American	2.57 ± 0.55	2.59 ± 0.50	2.54 ± 0.61

Table 4

Global Rim Area in Glaucoma Suspect and Glaucomatous Eyes by Race

Population	Number of Glaucoma Suspect and Glaucomatous Eyes (n,n)	Mean Global Rim Area, Glaucoma Suspect (mm^2) ± SD	Mean Global Rim Area, Glaucoma (mm^2) ± SD	Student's Ttest Comparing Means (P)
African-American	31,5	1.63 ± 0.41	1.51 ± 0.43	0.27
Asian-American	91,27	1.53 ± 0.38	1.57 ± 0.41	0.51
Caucasian-American	91,36	1.56 ± 0.40	1.41 ± 0.39	0.012
Filipino-American	35,4	1.70 ± 0.32	1.56 ± 0.68	0.33
Hispanic-American	29,9	1.60 ± 0.46	1.53 ± 0.43	0.57

Glaucomatous eyes include those with diagnoses of Primary Open Angle Glaucoma, Chronic Narrow Angle Glaucoma, Mixed-Mechanism Glaucoma, Normotension Glaucoma, Pseudo-exfoliative Glaucoma, pigmentary glaucoma, and traumatic glaucoma.

Table 5

Central Corneal Thickness, Spherical Equivalent, and Cylindrical Refraction by Race

Population	Mean CCT (μm) ± SD	Mean SE (diopters) ± SD	Mean Cylindrical Refraction (diopters) ± SD
African-American	528.9 ± 32.7	-0.24 ± 2.02	0.41 ± 0.65
Asian-American	539.0 ± 36.7	-0.85 ± 2.86	0.56 ± 0.71
Caucasian-American	554.8 ± 36.8	-0.94 ± 3.08	0.50 ± 0.69
Filipino-American	537.1 ± 31.2	-0.61 ± 3.84	0.41 ± 0.73
Hispanic-American	533.4 ± 31.2	-0.39 ± 2.17	0.71 ± 1.04