

Central corneal thickness distribution among patients diagnosed with systemic hypertension and diabetes mellitus: The Colombian glaucoma study

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Abstract

Objective: To establish the Central Corneal Thickness (CCT) distribution among patients diagnosed with systemic hypertension (SH) and diabetes mellitus (DM) in six cities of Colombia.

Methods: A cross-sectional study was conducted in Colombia among hypertensive and diabetic patients. This study included 2,067 subjects older than 50 diagnosed with SH and DM. Participants underwent a complete ophthalmic examination, including intraocular pressure (IOP) measurement by Goldmann tonometry, Central Corneal Thickness (CCT). The glaucoma diagnosis was confirmed by structural and functional evidence.

Results: The average central corneal thickness was 538.91 microns (μm). The mean CCT of males was significantly thicker (542.43 μm) when compared with females (536.96 μm) ($p < 0.001$). Glaucoma patients had thinner corneas (533.15 μm) than glaucoma suspects (535.99 μm) and non-glaucoma patients (539.15 μm) ($p < 0.044$). A decrease of approximately 2-3 μm was observed for each decade of life, 50 - 60 years (540.50 μm), 60 - 70 years (539.97 μm), 70 - 80 years (537.41 μm), older than 80 years (532.14 μm) almost reaching a statistically significant value ($p < 0.056$). Mestizo subjects had thicker corneas than white (caucasian) and African - descendants; 538.29 μm , 539.29 μm , 531.05 μm , respectively ($p < 0.012$). Patients with Intraocular Pressure (IOP) lower than 15 mmHg had thinner corneas than patients with IOP between 15 - 21 mmHg and higher than 21 mmHg; 536.92 μm , 543.41 μm , 559.50 μm , respectively ($p: 0000$).

Conclusions: CCT is thicker in males compared to females. Glaucoma patients had thinner corneas than glaucoma suspects and non-glaucoma patients. Older patients (>80 years) had thinner corneas than younger patients. Mestizo subjects had thicker corneas than white (caucasian) and African - descendants. Patients with lower Intraocular Pressure (IOP) had thinner corneas than patients with higher IOP mmHg.

Keywords: Open angle-glaucoma; Central Corneal Thickness; Systemic Hypertension; Diabetes Mellitus; Intraocular Pressure

1 Introduction

When Goldmann and Schmidt first described the Goldman applanation tonometry, they assumed no variations in the central corneal thickness (CCT) (1). With the creation of precise and accurate pachymeters, they realized that variations in CCT are a phenomenon to consider when assessing corneal health status, corneal diseases, intraocular pressure (IOP) values, eligibility for laser refractive surgery, corneal transplants and associated procedural complications, and risk profiling for ocular diseases such as ocular hypertension and glaucoma (2,3).

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CCT is related to demographic factors such as age and ethnicity. Foster et al. (4) and Brand et al. (5) reported a thinning of 10 μm per decade and 6.3 μm per decade in corneas, respectively. Concerning ethnicity, La Rosa et al. (6) reported that the average CCT in whites (approximately 556 μm) is more than the average CCT in African Americans (approximately 518-534 μm) (7–11,12,13. Foster et al. (4) reported a CCT in Mongolians of 495 and 514 μm in the right and left eye, respectively. Additionally, people from Japan (517-532 μm) (10,14,15) and India (511 μm) (16) have thinner corneas when compared with Caucasians (542-558 μm) (6,11,17), Chinese 542 μm (8), Korean 554 μm (18) and Hispanic 547 μm patients (19).

In 2002, Gordon M et al. published “The Ocular Hypertension Treatment Study: baseline factors that predict the onset of primary open-angle glaucoma” (OHTS) (20) where they found increased CCT measurements in ocular hypertensive subjects and described decreased CCT as a significant risk factor for the development of Primary open-angle glaucoma (POAG) in patients with ocular hypertension (OH). Since that moment, other studies like the European Glaucoma Prevention Study (EGPS) (21, 22), Early Manifest Glaucoma Trial (23), the Barbados Eye Study (24), and the Los Angeles Latino Eye Study (LALES) (25) were conducted and found similar results.

Regarding systemic diseases, the OHTS (5) described a higher CCT in patients with diabetes mellitus type 2 (DM) when compared with patients without diabetes, similar to the Barbados study results (11), the Singapore Malay Eye Study (26), The Liwan Eye study (27) and the Funagata study (28). Conversely, the OHTS (5) did not find a difference in patients reporting systemic hypertension.

To our knowledge, there are no population-based data on CCT measurements in the population of Colombia itself. The Colombian Glaucoma Study is a population-based eye survey of six cities in Colombia (31). This survey offers the opportunity to describe the distribution of CCT in a large Colombian population-based cohort of Hypertensive and Diabetic Patients.

2 Material and methods

2.1 Study Design

A cross-sectional study of diabetic and hypertensive patients in Colombia was conducted from September 2014 to January 2019. At enrollment, individuals were ≥ 50 and treated with antihypertensive and anti-diabetic medications for at least one year. The diagnosis of DM and SH was verified according to the guidelines for each disease (32,33). All participants were selected from SH and DM control programs. The Valle University Review Board approved this study (Approval Code 030-014), and all participants signed an informed consent form. This research was conducted according to the tenants of the Declaration of Helsinki.

2.2 Procedures

Interviews and questionnaires were used to evaluate factors related to participants’ lifestyles and other health conditions, including socioeconomic status, associated comorbidities, education, and nutrition. In addition, a physical examination was performed that included measurement of height, weight, abdominal circumference, heart rate and systolic blood pressure (SBP), and diastolic blood pressure (DBP).

2.3 Ophthalmic evaluation

Each participant underwent a complete ophthalmologic examination, including visual acuity, refraction, slit-lamp examination, intraocular pressure, and pachymetry measurements. The IOP measurement was obtained from the average of three values by Goldmann tonometry. Central corneal thickness (CCT) was calculated based on the average of three consecutive measurements using a PachPen handheld pachymeter (Accutome, iNC., Pennsylvania, USA).

In suspected cases of glaucoma, the diagnosis was confirmed using a visual field (VF) test with the 24-2 Swedish Interactive Threshold Algorithm (Humphrey, Carl Zeiss Meditec, Inc) and optic nerve photos with a DRS camera (digital retinography system, Centervue, Fremont, CA, USA). Reliable visual fields had rates of false-positive, fixation losses, and false-negative errors of 20% or less. Trained glaucoma specialists performed the examinations using standardized protocols.

2.4 Diagnosis of Glaucoma

Suspected and confirmed cases of glaucoma were defined according to the criteria specified by Foster et al. (34) confirmed glaucoma was defined as structural and functional evidence of glaucomatous damage in at least one eye.

2.5 Statistical Analysis

Continuous variables were summarized with mean± standard deviation (SD) or median and Interquartile range (IQR), while categorical variables were described with proportions.

The patients were divided into three groups according to the status of diagnosis of Glaucoma: confirmed cases, suspected cases, and those without glaucoma. Binary and categorical characteristics were compared using chi-square or Fisher's exact tests. Odds Ratios (OR) Were estimated with a 95% confidence interval, and goodness-of-fit was evaluated using a likelihood ratio test and the minor model deviance. A level of significance of 0.05 was used. All analyses were carried out using Stata13® (STATA Corp, College Station, TX, USA).

3 Results

A total of 2085 subjects completed the interview and ophthalmologic examination, of which 18 were excluded because they met one or more exclusion criteria. The average age of the 2067 participants was 65.6±8.8 years; 65.93% (1324) were female, 11.0% (227) had only DM, 59.6% (1231) had only SH, and 29.4% (608) had both diseases. Of 2067 patients, 142 were identified with confirmed glaucoma and 226 subjects with suspected glaucoma. (31)

Of 2067 SH and DM patients, 1974 had CCT measurements. The average central corneal thickness was 538.91 μm (figure 1). 702 male and 1272 female subjects had CCT measurements. The mean CCT of males was significantly thicker (542.43 μm) when compared with females (536.96 μm) ($p < 0.001$). Glaucoma patients had thinner corneas (533.15 μm) when compared with glaucoma suspects (535.99 μm) and non-glaucoma patients (539.15 μm) ($p < 0.044$). (Table 1)

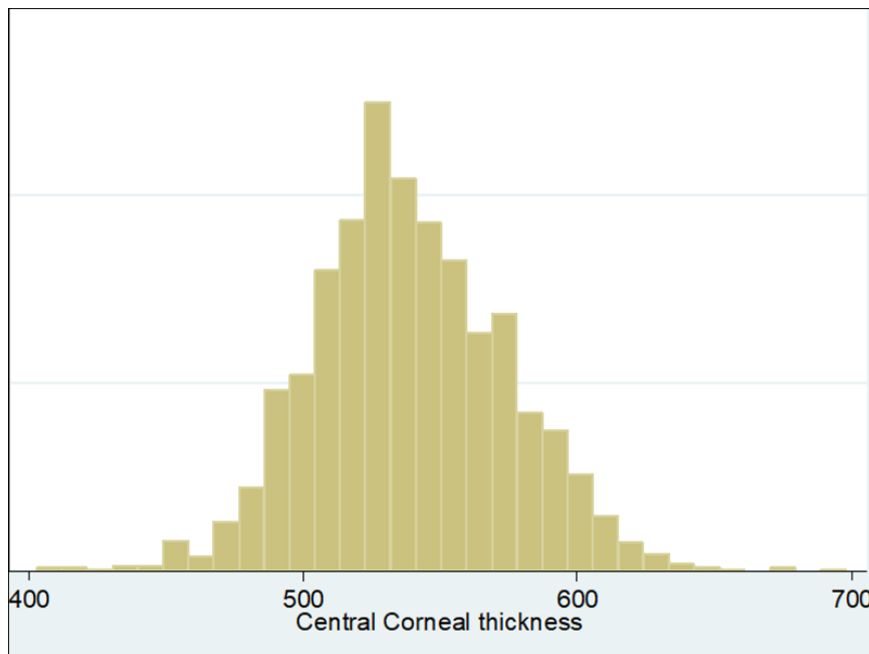


Figure 1 Distribution of Central Corneal Thickness (microns)

Concerning age, a decrease of approximately 2-3 μm was observed for each decade of life, 50 - 60 years (540.50 μm), 60 - 70 years (539.97 μm), 70 - 80 years (537.41 μm), older than 80 years (532.14 μm) almost reaching a statistically significant value ($p < 0.056$). Regarding ethnicity, Mestizo subjects had thicker corneas than white (caucasian) and African - descendants; 538.29 μm , 539.29 μm , 531.05 μm , respectively, with a level of significance ($p < 0.012$). (Table 1) Concerning IOP, patients with IOP lower than 15 mmHg had thinner corneas than patients with IOP between 15 - 21 mmHg and higher than 21 mmHg; 536.92 μm , 543.41 μm , 559.50 μm , respectively ($p: 0000$). Table 1 and Figure 2

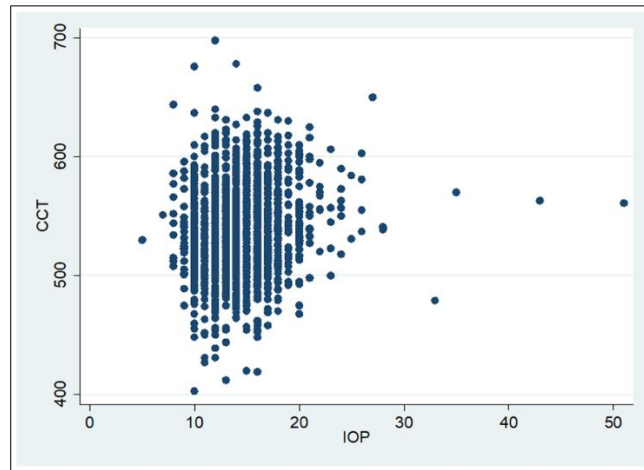


Figure 2 Relation of IOP (mmHg) and CCT (μm)

Table 1 Central Corneal Thickness distribution

	Central corneal thickness (microns)			
	n	Mean	Std.Devi.	P. value
Sex				
Male	702	542.4387	35.08609	
Female	1,272	536.9615	35.6054	<0.001
Primary open Angle Glaucoma				
Positive	140	533.12	36.396878	
Negative	1,612	539.812	35.488836	
Suspect	222	535,9865	34.748675	0.83
Age (years)				
50-59	543	540.5009	34.090333	
60-69	773	539.9703	36.867188	
70-79	526	537.4068	35.101782	
>80	132	532.1364	34.095683	0.056
Ethnicity				
Mestizo	1575	539.79	34.82	
African descendent	157	531.05	34.18	
White	242	538.29	40.03	0.012
Intraocular pressure				
<15 mmHg	1440	536.92	34.85	
15-21 mmHg	496	543.42	36.85	
>21 mmHg	32	559.5	33.23	0.000
Total	1,974	538.9093	35.509675	

4 Discussion

4.1 CCT and sex

Our results concluded that the mean CCT of males was thicker (542.43 μm) when compared with females (536.96 μm) ($p < 0.001$), similar to what was found in a study with Taiwanese adults (29), the European glaucoma prevention study (2) and a multiethnic population (30), in contrast with findings in the OHTS study (5) where females had slightly thicker corneas (5 μm) than their male counterparts.

4.2 CCT and Glaucoma

In our study, Glaucoma patients had thinner corneas (533.15 μm) in comparison with glaucoma suspects (535.99 μm) and regular patients (539.15 μm) ($p < 0.044$), similar to what was described in the Barbados study (11) whereas CCT decreases, POAG risk increase with 40% higher likelihood of POAG per 40 μm thinner CCT (OR, 1.41). Likewise, the Los Angeles Latino Eye Study (LALES) (25) found thinner corneas in glaucomatous patients (544.6 μm) in comparison with ocular hypertensive patients (561 μm) and normal patients (546.5 μm), they conclude that low CCT $< 504 \mu\text{m}$ is a significant risk factor for glaucoma. In comparison to the Tema Eye Survey in Africa (3) that described a CCT in the population of $533.9 \pm 34.0 \mu\text{m}$ but in the multivariable linear regression analysis, there was a significant association with higher IOP ($P < .001$) but not with glaucoma.

4.3 CCT and Age

We observed a decrease of approximately 2 -3 μm for each decade of life, 50 - 60 years (540.50 μm), 60 - 70 years (539.97 μm), 70 - 80 years (537.41 μm), older than 80 years (532.14 μm) almost reaching a statistically significant value. ($p < 0.056$). Similar to what was described by Foster et al. (4) and by Brand et al. (5). Gordon et al. (20) reported a thinning of 10 μm per decade and 6.3 μm per decade in corneas, respectively.

4.4 CCT and ethnicity

The average central corneal thickness of our study was 538.91 μm . Concerning ethnicity, La Rosa et al. (6) reported that the average CCT in whites (approximately 556 μm) is more than the average CCT in African Americans (approximately 518-534 μm), similar to what was reported by Wang et al. in a multiethnic population study (30) where Blacks had 537.3 μm , SD 39.9 and the thickest corneas were reported in Whites 558.5 μm , SD 40.3, and corneas of intermediate thickness among Asians and Hispanic. Foster et al. (4) reported a CCT in Mongolians of 495 and 514 μm in the right and left eye, respectively. Additionally, people from Japan (517-532 μm) (10) (14)(15) and India (511 μm) (16) have thinner corneas when compared with Caucasians (542-558 μm) (6)(11)(17), Chinese 542 μm (8), Korean 554 μm (18) and Hispanic 547 μm patients (19).

4.5 CCT and IOP

Patients with IOP lower than 15 mmHg had thinner corneas than patients with IOP between 15 - 21 mmHg and higher than 21 mmHg; 536.92 μm , 543.41 μm , 559.50 μm , respectively ($p: 0000$). The Chennai Glaucoma Study, an Indian study based population (16), a Japanese based population study (14) and the Angeles Eye Latino Study Group (25) also described a higher IOP range associated with a significantly greater CCT.

This study, to our knowledge, is the first population-based study to describe the Central Corneal Thickness distribution among patients diagnosed with Systemic Hypertension and Diabetes Mellitus in patients over 50 years of age in Colombia.

Our study included two essential vascular risk factors for glaucoma. The implementation of standardized protocols for conducting the study makes the information collected from the six participating cities comparable, increasing the quality of the information. Furthermore, the sociodemographic and risk factors surveys were performed before the ophthalmologic evaluation, which would reduce a differential information bias between patients diagnosed with suspicious or confirmed POAG compared with healthy subjects.

Due to our study's cross-sectional design, it is impossible to establish causal associations conclusively. However, these findings represent a starting point for further studies that evaluate the biological association between Central Corneal thickness in patients with SH and DM.

5 Conclusion

In summary, CCT is thicker in males compared to females. Glaucoma patients had thinner corneas than glaucoma suspects and non-glaucoma patients. Older patients (>80 years) had thinner corneas than younger patients. Mestizo subjects had thicker corneas than white (caucasian) and African - descendants. Patients with lower Intraocular Pressure (IOP) had thinner corneas than patients with higher IOP mmHg.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declared no conflict of interest.

Statement of ethical approval

The Universidad del Valle Review Board approved this study (Approval Code 030-014), and all participants signed informed consent. This research was conducted according to the Declaration of Helsinki.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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