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ORIGINAL ARTICLE

Ophthalmology

Association Between Central Corneal Thickness and Intraocular Pressure in Patients with Refractive Anomalies and Emmetropes

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Abstract

Background: The aim of this study was to determine the relationship between central corneal thickness (CCT) and intraocular pressure (IOP) in patients with refractive anomalies and emmetropes.

Methods and Results: This retrospective study was conducted in the Department of Ophthalmology at the University Clinical Center. The study included 330 respondents, with a total of 660 eyes, divided into two groups. The test group (TG) included 180 respondents with refractive anomalies (65 respondents with hypertropia, 65 with myopia, and 50 with astigmatism); the control group (CG) included 150 respondents with uncorrected visual acuity – 6/6 in both eyes. All respondents included in the research were aged 18–40, with an average age of 22.9 years. The values of CCT in TG was around 499.3–577.1 µm. From 360 eyes in the TG with refractive anomalies, the highest IOP values were found in the astigmatic group (20.6 mmHg) and the lowest values in the myopic group (15.3 mmHg) (P<0.001) and were statistically higher compared to the CG (P<0.001 in both cases). We found a statistically significant, moderate positive correlation between the values of CCT and IOP in the hypermetropic group (r_s=0.655, 95% CI: 0.540 to 0.745, P<0.0001) and a statistically significant low negative correlation (r_s=-0.209, 95% CI: -0.373 to -0.033, P=0.0165) between the values of CCT and IOP in the myopic group. Also, a statistically significant low negative correlation (r_s=-0.304, 95% CI: -0.510 to -0.152, P=0.0005) was found between the values of CCT and IOP in the astigmatism group.

Conclusion: The results of our study show that increasing the CCT values in the hypermetropic group leads to an increase in the IOP values. Therefore, these findings can be used as a reference for our population, which would assist in the early diagnosis of ocular hypertension. (**International Journal of Biomedicine. 2023;13(3):91-95.**)

Keywords: central corneal thickness • refractive anomaly • intraocular pressure

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Abbreviations

CCT, central corneal thickness, **DS**, diopter sphere; **DC**, diopter cylinder; **GAT**, Goldmann applanation tonometry; **IOP**, intraocular pressure.

Introduction

Central corneal thickness (CCT), a crucial indicator of a healthy cornea, helps to evaluate corneal diseases.[1] CCT, as well as intraocular pressure (IOP), is important for assessing glaucoma, considering that low CCT will lead to the underestimation of intraocular pressure and interfere with the prognosis of glaucoma.[2] IOP is a key element in the management of glaucoma, and it should, therefore, be measured using a reliable technique with a high degree of accuracy. Though Goldman applanation tonometry (GAT) is the most widely used and current "gold standard" for IOP measurements, readings of IOP measurements made with GAT are affected by CCT.[3,4]

Refractive errors constitute one of the most common causes of visual impairment affecting all age groups.[5] Refractive error is another factor associated with CCT in adults and children, with high myopic refractive errors reported to have reduced CCT compared, to those with greater hyperopic refraction.[6-9]

The aim of this study was to determine the relationship between CCT and IOP in patients with refractive anomalies and emmetropes.

Materials and Methods

This retrospective study was conducted in the Department of Ophthalmology at the University Clinical Center. The study included 330 respondents, with a total of 660 eyes, divided into two groups. The test group (TG) included 180 respondents with refractive anomalies (65 respondents with hypertropia, 65 with myopia, and 50 with astigmatism); the control group (CG) included 150 respondents with uncorrected visual acuity – 6/6 in both eyes. All respondents included in the research were aged 18–40, with an average age of 22.9 years.

Data collection

Emmetropic respondents were selected after a detailed examination. Refractive anomalies were presented by the spherical equivalent refraction calculated as sphere plus half of the cylindrical error. The respondents were classified according to the spherical power into three major groups: emmetropic group (+0.25 to −0.25 D), myopic group (≥−0.50D), and hypermetropic group(≥+0.50D); furthermore, according to the cylindrical equivalent some respondents were classified into the astigmatism group (≥−0.5 DC to + ≥0.5 DC). The hypermetropia and myopia groups were divided into three subgroups based on refractive power: mild (≤3.00 DS), moderate (3.00-6.00 DS), and high (>6.00 DS).

Based on the focus of the main meridians in the astigmatic group, the respondents were classified into these subgroups: myopic astigmatism, hypermetropic astigmatism, compound astigmatism, and mixed astigmatism. Myopic astigmatism was determined in respondents who had a negative (sphere and cylinder) error of ≥-0.50DC, and hypermetropic astigmatism was determined in respondents who had a positive (sphere and cylinder) error of ≥+0.50DC.

In the subgroup of myopic compound astigmatism, respondents were classified into the group where both the sphere and cylinder had negative diopters (≥ −0.50D and ≥ −0.50DC), as well as the group of compound hypermetropic astigmatism (≥ +0.50D and ≥ +0.50DC). Meanwhile, the mixed astigmatism group included respondents with a positive sphere (+0.50D) and a negative cylinder (-0.50DC), or the opposite.

Inclusion criteria, respondents with the following: previously undiagnosed refractive anomalies, need for correction of refractive anomalies, normal corneal topography, no ocular disease, no previous eye surgery, and no previous correction with glasses.

Exclusion criteria, patients with the following: glaucoma and previous corneal refractive surgery procedures; IOP>21 mmHg; evidence of other anterior segment pathology, including corneal opacities, keratoconus, corneal oedema, presbyopia, amblyopia, staphyloma; best visual acuity of 6/6 (also expressed as 20/20 or 1.0); diabetes mellitus or other acute or chronic diseases possibly affecting the corneal thickness; no history of contact lens wear; encroached pterygium; refusal to give consent.

Procedure

Data collected from respondents with refractive anomalies were retrospectively collected for 360 eyes examined over a period of two years, thereafter compared with data from normal eyes. After informed consent was obtained, the respondents underwent a complete ophthalmic examination and anterior segment evaluation biomicroscopy. Visual acuity was measured at 6 meters (20 feet) using a Snellen chart.

IOP measurement by GAT: three measurements were taken, and the average was calculated, optic axis length measurement with ultrasound A scan, corneal curvature measurement with the automated keratometry, and 90D cycloplegia fundus exam.

CTT measurement was initially performed on all respondents with refractive anomalies as well as the CG. CCT was measured by ultrasonic pachymetry, five CCT measurements were taken, and the average was used for analysis. The visual acuity was determined using mydriatic points, then under the influence of the mydriatic, with Hydrochloride Cyclopentolate (one drop of 1% solution). A cyclopentolate drop was instilled two times at an interval of 10 minutes, and refraction was carried out after 45 minutes after the first instillation. Cycloplegia was considered complete if the pupil was dilated to 6 mm or more and no light reflex was present. On completion of testing the right eye, the acuity of the left eye was measured. Results were the same when the left eye was analyzed; thus, right-eye data were presented.

Statistical analysis was performed using the statistical software package SPSS version 22.0 (SPSS Inc, Armonk, NY: IBM Corp). For the descriptive analysis, results are presented as mean (M) ± standard deviation (SD). For data with normal distribution, inter-group comparisons were performed using Student's t-test. A non-parametric Kruskal-Wallis test was used to compare median values among ≥3 groups, followed by Dunn's test to identify which groups are different. Categorical variables were analyzed using the chi-square test with Yates' correction or, alternatively, Fisher's exact test. Spearman's rank correlation coefficient (r_s) was calculated to measure the strength and direction of the relationship between two variables. A probability value of $P<0.05$ was considered statistically significant.

Results

By categorizing respondents by gender, we found no difference with a significant statistical value. Most of the surveyed respondents (75.2%) from the four groups were between 20–29 years. All respondents included in the research were aged 18–40, with a mean age of 22.9±4.0 years. According to age, we found statistically significant differences between the groups ($P=0.0002$). Respondents with astigmatism were younger than the group with hypermetropia ($P<0.01$) and myopia ($P<0.01$) (Table 1).

The values of CCT in TG was around 499.3–577.1 μm. We found a statistically significant difference between the CCT of the three groups—hypermetropia, myopia, and astigmatism—and the CG ($P<0.001$) (Table 2). Also, compared with the CG, we obtained a statistically significant difference in the IOP value in all groups with refractive anomalies (P<0.0001) (Table 3). From 360 eyes in the TG with refractive anomalies, the highest IOP values were found in the astigmatic group (20.6 mmHg) and the lowest values in the myopic group (15.3 mmHg) (P<0.001) and were statistically higher compared to the CG (P<0.001 in both cases) (Table 3).

Table 1.
General characteristics of study patients

	Hypermetropic group n=65	Myopic group n=65	Astigmatism group n=50	Control group n=150	*P*-value
Gender, n (%)					
F	45(69.2)	41(63.1)	32(64.0)	94(62.7)	0.824
M	20(30.8)	24(36.9)	18(36.0)	56(37.3)	
Age, mean±SD (year)	23.8±4.9	24.2±5.6	21.6±2.1	22.3±2.7	0.0002
Age group (year) n (%)					
< 20	11(16.9)	12(18.5)	10 20.0)	30(20.0)	0.0057
20-29	47(72.3)	43(66.2)	40(80.0)	118(78.7)	
≥30	7(10.8)	10(15.4)	-	2(1.3)	

Table 2.
Central corneal thickness by groups

CCT (µm)	n	Mean ±SD	*P*-value
Hypermetropia	65	561.5±25.3	Hypermetropia
high	7	569.5±23.2	High vs.Con., P<0.05
moderate	15	577.1±40.2	Moderate vs.Con., P<0.001
low	43	559.7±21.5	Low vs.Con., P<0.001
Myopia	65	517.9±37.3	Myopia
high	5	507.3±50.8	High vs. Con., P<0.001
moderate	9	499.3±41.8	Moderate vs. Con., P<0.001
low	51	526.0±34.5	Low vs. Con., P<0.001
Astigmatism	50	528.3±35.3	Astigmatism
hypermetropic	10	547.8±27	Hypermetrop.vs. Con.,P>0.05
myopic	21	518.2±24.6	Myopic vs. Con., P<0.001
mixed	11	549.4±41.5	Mixed vs. Con., P>0.05
compound	8	514.1±36	Compound vs. Cont., P<0.001
Control (Con.)	150	553.3±18.5	
Kruskal Wallis test		P<0.001	
Dunn's test Hypermetropia vs. Myopia [P<0.001]; Hypermetropia vs. Astigmatism [P<0.001]; Hypermetropia vs. Control [P>0.05]; Myopia vs. Astigmatism [P>0.05]; Myopia vs. Control [P<0.001]; Astigmatism vs.Control [P<0.001].			

IOP, mmHg	Group			
	Hypermetropia	Myopia	Astigmatism	Control
n	65	65	50	150
Mean	19.9	15.3	20.6	12.3
SD	5.0	4.7	4.9	3.0
Min	10	10	10	10
Max	26.5	24.5	29	21
Kruskal Wallis test P<0.0001				
Dunn's test Hypertropia vs. Myopia [P<0.001]; Hypertropia vs. Astigmatism [P>0.05]; Hypertropia vs. Control [P<0.001]; Myopia vs. Astigmatism [P<0.001] Myopia vs. Control [P<0.001]; Astigmatism vs. Control [P<0.001]				

We have analyzed the degree of correlation between the values of CCT (µm) and IOP (mmHg) in the hypermetropic group, where a statistically significant, moderate positive correlation was found (r_s=0.655, 95% CI: 0.540 to 0.745, P<0.0001), (Figure 1). A statistically significant low negative correlation (r_s=-0.209, 95% CI: -0.373 to -0.033, P=0.0165) was found between the values of CCT and IOP in the myopic group (Figure 2). Also, a statistically significant low negative correlation (r_s=-0.304, 95% CI: -0.510 to -0.152, P=0.0005) was found between the values of CCT and IOP in the astigmatism group (Figure 3). No significant correlation (r_s=0.074, 95% CI: -0.042 to 0.189, P=0.197) was determined between the values of CCT and IOP in the CG (Figure 4).

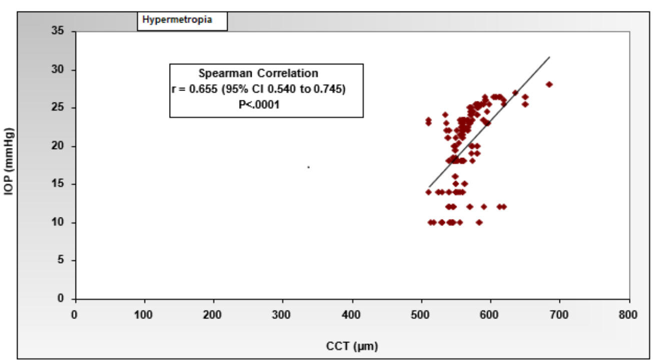

Fig. 1. *Correlation between CCT and IOP in the hypermetropic group.*

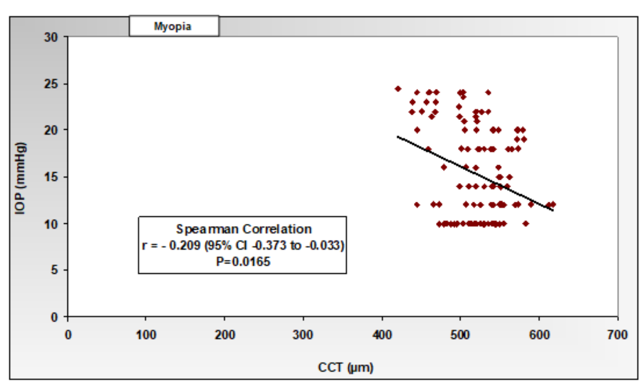

Fig. 2. *Correlation between CCT and IOP in the myopic group.*

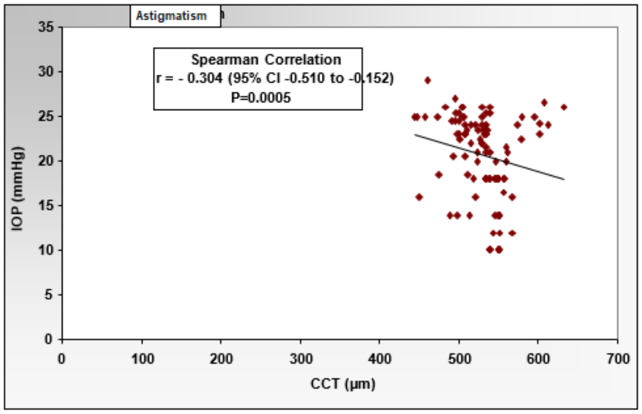

Fig. 3. *Correlation between CCT and IOP in the astigmatism group.*

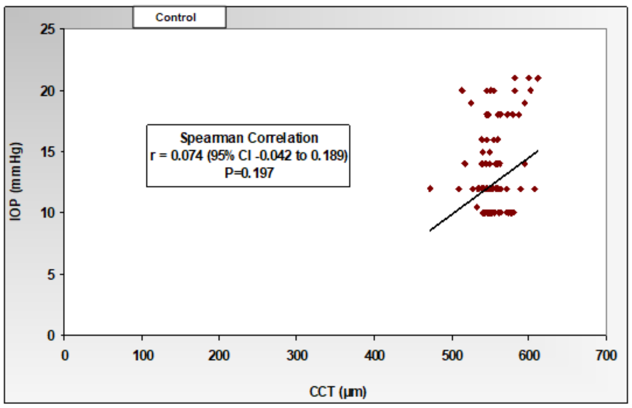

Fig. 4. *Correlation between CCT and IOP in the control group.*

Discussion

In a study by Juwayli et al.,[10] the average age of the myopic study group was 32.3±5.61years, while in the hypermetropic group - 35±6.59 years, ranging from 20 to 40 years. Women dominated in both groups; there were 25 myopic and 25 hyperopic eyes.[10] In our study, the average age was 22.9, range 18-40, and it also included astigmatic respondents (Table 1). A study by Qayum et al.[11] found that CCT was associated with IOP in both genders. These results were consistent with our findings.

We also found a statistically significant difference between the CCT values of the three groups—hypermetropic, myopic, and astigmatic—and the CG (P<0.001) (Table 2). In the hypermetropic group, the mean value of CCT was higher than in the CG (emmetrope). Many researchers have reported a correlation between CCT and IOP measurements using the GAT method. An increasing number of new methods for IOP measurement have become the object of many studies, which compare them with the GAT method, which is still considered to be the standard method.[12]

In this study, using GAT methods, we found that the average IOP value of our respondents was 12.3mmHg.[13] This is consistent with other studies. Ehlers et al.[14] showed a 5 mm mmHg increase in IOP for every 70-µm increase in CCT, while a study by Wei et al.[15] reported a 0.32 mmHg increase in IOP for every 10-µm increase in CCT.

Many studies found a positive association between IOP and CCT measured by applanation and a possible overestimation. Numerous studies have shown that patients diagnosed with ocular hypertension have significantly thicker corneas than normal subjects.[16,17] But in our study, the respondents did not have a positive history of glaucoma. From 360 eyes in the TG with refractive anomalies, the highest IOP values were found in the astigmatic group (20.6 mmHg) and the lowest values in the myopic group (15.3 mmHg) (P<0.001) and were statistically higher compared to the CG (P<0.001 in both cases) (Table 3).

A study by Hoffmann et al.[8] with the pachymetry method showed that a normal range of the values of CCT was around 520–550 µm. They concluded that variability in CCT measurement could be a reason for error with GAT, where thick cornea may cause an overestimation of IOP values. Also, the results of our study show that these reasons can affect the IOP values measured with the GAT method.

The relationship between refractive anomalies and IOP is another area of discrepancy. Some studies have suggested that myopia may be associated with the risk of primary open-angle glaucoma and hypermetropia with a possible risk of ocular hypertension.[18] Most of the studies have focused mainly on myopic and hypermetropic eyes, but we have also included astigmatic eyes in our study.

Regarding the relationship between IOP and refractive errors, a study conducted in Wisconsin[16] showed that myopes were 60% more likely to develop glaucoma than emmetropes. A study by Nomura et al.[19] found a positive relationship between IOP and increasing degrees of myopia; unlike our results, a correlation was found between IOP and the myopic group, regardless of the degree of myopia. Such results have been encountered in other studies, such as a study by Mana, who found a weak but significant correlation between GAT-IOP and corneal astigmatism.[20] Meanwhile, our study found a statistically significant low negative correlation between the values of CCT and IOP in the astigmatic group (Figure 1). We obtained a statistically significant difference between the values of the CCT and IOP of the hypermetropic, myopic, and astigmatic groups, compared with the CG (P<0.001) (Figures 1-4). In our results, of the 360 eyes in the TG, the highest IOP values were found in the astigmatic group (20.6 mmHg), while the lowest values were in the myopic group (15.3 mmHg).

In conclusion, the results of our study show that increasing the CCT values in the hypermetropic group leads to an increase in the IOP values. Also, these results showed that the mean IOP measured by the applanation tonometer was 12.3 mmHg in control, and the highest IOP values were found in the astigmatic group (20.6 mmHg). Therefore, these findings can be used as a reference for our population, which would assist in the early diagnosis of ocular hypertension.

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Competing Interests

The author declares that there is no conflict of interest.

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