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Original Article

The Association of Central corneal thickness with Intra-ocular Pressure and Refractive Error in a Nigerian Population

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Abstract:

The purpose of this study was to determine the variation of central corneal thickness (CCT) with intraocular pressure (IOP) and spherical equivalent refractive error. A total of thirty-nine (N=39) subjects within 20-75 years with mean age 45.2 ± 15.4 years were used for this study. The central corneal thickness was assessed with the Corneo-Gage plus ultrasonic Pachymeter, the IOP with slit-lamp mounted Goldmann applanation tonometer and refractive status by Protec 2000 autorefractor, phoropter and trial lens set. Results obtained showed that there was no linear correlation between CCT and spherical equivalent errors, although the association between them was significant ($p<0.05$). The linear correlation between CCT and IOP was not statistically significant. The central corneal thickness was weakly correlated with age; with increasing age the central corneal thickness decreases. Neither the central corneal thickness nor the intraocular pressure was affected by gender.

Key Words: Central corneal thickness, Intraocular pressure, Spherical equivalent refractive error, Mean spherical equivalent myopia, Mean spherical equivalent hyperopia.

Introduction:

The early description of the applanation tonometer considered the possible influence of corneal thickness on the intraocular pressure (IOP) as measured with the Goldmann applanation tonometer (GAT). Goldmann applanation tonometry is the international 'gold standard' technique for IOP measurements.(1,2) With the introduction of ultrasonic pachymeters, it became apparent that variations in corneal thickness are much more widespread than once believed. The ultrasound pachymetry is the most widely used technique for in vivo corneal thickness measurement.(3) Doughty and Zaman (4), reported that the mean central corneal thickness (CCT) in normal eyes was 534µm while for ultrasonic pachymetry, the mean CCT was 544µm. The average central corneal thickness measures from 535 - 565µm, although ethnic differences are likely.(5)

Studies have shown that IOP measurement with GAT is affected by changes in the central corneal thickness. (2,6-15) The risk factor that has had the biggest impact on screening for the glaucoma (an eye disease characterized by persistent raise in IOP that ultimately damage the optic nerve irreversibly if not properly managed) is CCT. The role of CCT as an important factor in individuals with elevated IOP and primary open-angle glaucoma (POAG) has been investigated.(16) The CCT has been considered as a masking factor hiding elevated IOP rather than independent risk factor.(17)

Nemesure et al (18) found that central corneal thickness was directly related to refractive errors, although no systemic alteration in CCT was found in myopia. Similarly, Lene and Neils (19) claimed that the process by which myopia progresses does not to a measurable degree influence the CCT. Over time it has been shown that myopic refractive errors are associated with thin CCT. Duch et al posited that high ametropia (refractive error) may bias the measurement of central corneal thickness.(20)

Hidek et al (21) in their investigation found a significant relationship between IOP and refractive error. However, Daubs and Crick (22) found no relationship between refractive error and ocular tension.

The aim of this study was to investigate the variation of central corneal thickness with intraocular pressure and refractive errors in A Nigerian population

Methods:

This was a prospective, cross-sectional study with a sample size of thirty-nine (N=39) made up of males (n=21) and females (n=18). A total of 78 eyes were examined. The subjects were within 20-75 years and had no detectable systemic or ocular pathologies that could affect the outcome of the study. The subjects were divided into two groups: hyperopia and myopia. The second author as part of her thesis work collected the data for this study during externship at 20-20 Eye centre, Ikeja, Lagos.

Admittance into this study was made after detailed optometric examination was carried out.

Instrumentation

A Haag-Streit slit-lamp biomicroscope mounted Goldmann applanation tonometer (GAT) was used throughout the study to measure the intraocular pressure (IOP). The refractive status was assessed objectively with Protec2000 Autorefractor and subjectively using a phoropter and trial lens set. A Corneo-Gage™ ultrasonic Pachometer was used to measure CCT (µm).

Procedure

All the subjects were first refracted to determine their refractive status. Measurements of refractive status were taken with the autorefractor after adequate preparation of subjects. Readings were refined subjectively using the phoropter. The spherical equivalents of the refractive errors were obtained using the expression: $F_E = F_{csin}{}^2\theta$, where F_E is spherical equivalent, F_s is spherical power and F_c, the cylinder power and θ, the cylinder axis.

The central corneal thickness was assessed with the pachymeter by placing the sterilized probe on the anaesthetized cornea (by applying tetracaine Hcl 0.1% to the eye). Measured CCT for the subject was taken as the average of five different readings and recorded in microns (µm).

The IOP was assessed with the Slit-lamp mounted Goldmann applanation tonometer after sterilizing the tonometer probe with hydrogen peroxide and applying tetracaine Hcl 0.1% and staining the eye with wetted fluorescein strip. Three consecutive readings are taken and the average recorded as measured IOP (mIOP) in mmHg.

Note that the IOP measurements were taken 10 minutes after pachymetry.

All measurements of CCT and IOP were taken between 9am and 12 noon to avoid diurnal variation. (23, 24)

The statistical tests used in this work were the Kolmogorov-Smirnov Z test, Unpaired t-test, Pearsons correlation coefficient, Linear regression, p values less than or equal to 0.05 (5%) were considered statistically significant.

Results:

A total of thirty-nine (N=39) subjects consisting of males (n=21) and females (n=18) within 20-75 years with mean age of 45.2 ± 15.4 years were used for this study. Of all the subjects, twenty four had hyperopia and 15 had myopia. The mean hyperopia was +1.00 ± 0.60D (OD) and +1.00 ± 0.70D (OS) while the mean myopia was -2.75 ± 1.70D (OD) and -2.25 ± 1.50D (OS) [Table 1].

Table 1. Mean, standard deviation and confidence interval of Refractive Error

Refractive Error	Mean ± SD RE (D)	95% confidence interval Mean ± SEM (D)
Myopia		
OD	-2.75 ± 1.7	-1.8 to -3.7
OS	-2.25 ± 1.5	-1.4 to -3.0
Hyperopia		
OD	+1.00 ± 0.6	+0.75 to +1.25
OS	+1.00 ± 0.7	+0.70 to +1.30

Although readings were obtained for both eyes, to avoid duplication of results only the readings of the right eye (OD) were used for analysis.

Table 2. Mean, standard deviation and confidence interval of IOP of subjects with Refractive Error

Refractive Error	IOP (mmHg) Mean ± SD	95% confidence interval Mean ± SEM
Myopia	14.0 ± 4.0	12.0 – 16.0
Hyperopia	14.0 ± 3.7	12.4 – 15.6

Table 3. Mean, standard deviation and confidence interval of CCT of subjects with Refractive Error

Refractive Error	CCT (µm) Mean ± SD	95% confidence interval Mean ± SEM
Myopia	548 ± 29.6	533-565
Hyperopia	549 ± 38.4	534 – 560

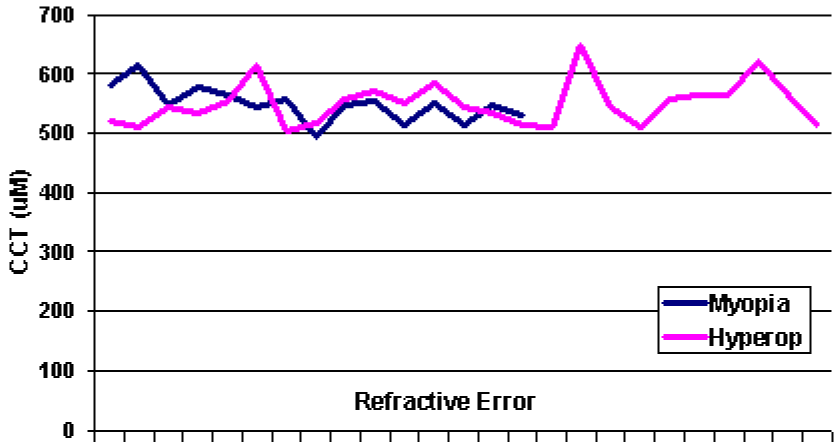

Fig. 1 The distribution of CCT with Refractive Error

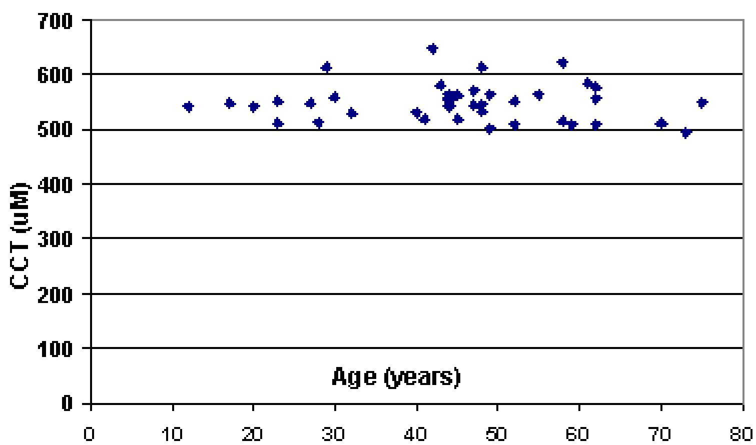

Fig. 2 Scattergram of CCT (µm) versus Age (years)

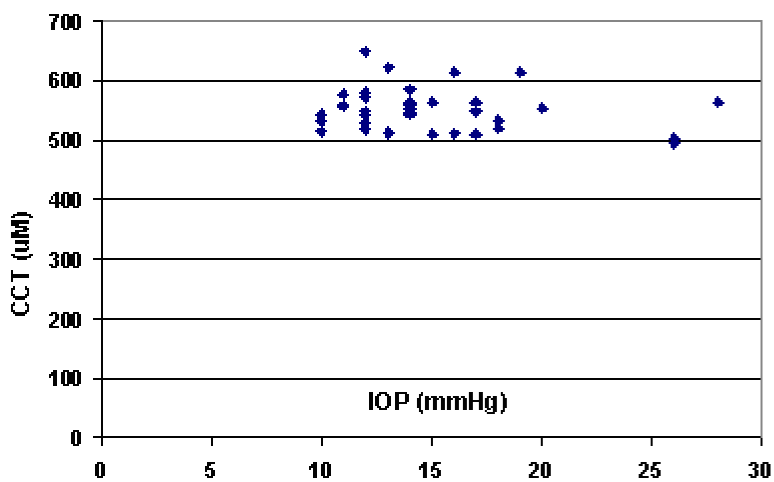

Fig. 3 Scattergram of CCT (µm) versus IOP (mmHg)

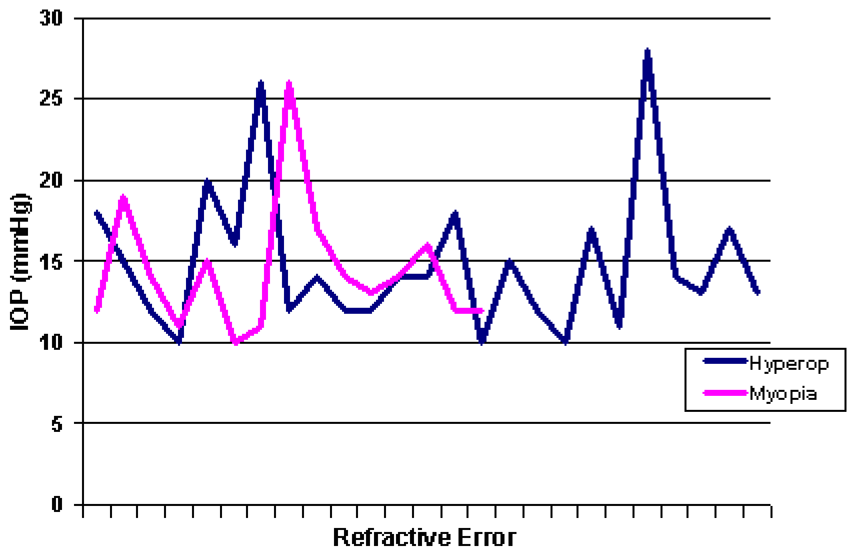

Fig. 4 The distribution of IOP (mmHg) with Refractive Error

Figs 1-4 show the scatter plot of CCT vs Refractive Error, CCT vs Age, CCT vs IOP and IOP vs Refractive Error respectively. There was no significant difference in mean CCT between males and females (Unpaired t-test: t=1.37, df=23, p>0.05). Similarly, the difference in mean IOP between males and females was not statistically significant (t=0.96, df=23, p>0.05). Summarily, neither CCT nor IOP was affected by gender.

Discussion

Goldmann applanation tonometry is widely accepted as international gold standard for the intraocular pressure measurement and is the most commonly used method.(1,2) Intraocular pressure measurement by Goldmann applanation tonometry varies with the thickness of the central cornea, the thicker the cornea the higher the measured IOP.(7,12,13) The central corneal thickness is measured with an instrument called the pachymeter. Goldmann tonometry is known to give reliable results on "normal corneae" (i.e., corneal thickness not too different from 520µm.(8) Hoffmann et al (25) reported a normal range 520-550µm by pachymetry. The inter-patient variation in CCT could be a source of error with Goldmann tonometry, where thick corneae cause over-estimation of IOP.(26) Gordon and colleagues in their ocular hypertension treatment study showed that the risk of someone who is greater than 60 years of age, with ocular hypertension of greater than 25.75mmHg and cup-to-disc ratio of 0.5 developing primary open-angle glaucoma is 50%. The patient with corneal thickness greater than 588µm is likely to progress to POAG. Patients with normal tension glaucoma have a higher incidence of thinner corneae.(17) Population-based studies have shown that there is an increased incidence of glaucoma in myopic patients.(27) Valiki and colleagues (28) reported that treatment for eyes with a mean myopic correction of 5.66D showed little or no effect on intraocular pressure as measured with applanation, tono-pen, or pneumotonometer. The result obtained from this study showed that refractive error has no effect on the IOP. Pearson correlation coefficient showed that there was no significant association between IOP and MSEM (r=0.025, p>0.05) but there was a strong negative correlation between IOP and MSEH (r=0.35, p<0.05) although the linear regression was not statistically significant (ANOVA: F=3.35, p=0.08). This finding was consistent with the study of Lee et al (29) who assessed whether IOP is associated with refractive error or axial length and found that neither spherical equivalent refractive error (r=0.014, p>0.05) nor axial length (r=0.027, p>0.05) were significantly associated with IOP. Lleo et al (30) also showed in their study that there was no significant correlation between mean spherical equivalent refraction and IOP (r=0.054, p=0.231). However, Wong et al (31) reported that in their study population, subjects with myopia were 60% more

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likely to have prevalent glaucoma in contrast to subjects with hyperopia who were 40% more likely to have incident ocular hypertension.

Our study has shown that there was a strong association between CCT and MSEM (r=0.32, p<0.05) but the linear regression was not statistically significant. Similarly, there was a slight association between CCT and MSEH (r=0.21, p<0.05) and the linear regression was equally not significant. Summarily, no linear prediction can be made about CCT and mean spherical equivalent refraction. This was consistent with findings of Lene et al (19) who reported that CCT was not systemically altered in myopia. Similarly, Ehlers et al (7) and Price and colleagues (32) claimed that CCT does not appear to be correlated with refraction. On the contrary, Nemesure et al (18) posited that CCT was directly related to refractive error, but high ametropia may bias the measurement of CCT. (20) In this study it was shown that the difference in mean CCT between males (561.8 ± 44.9µm) and females (541.5 ± 31.1µm) was not significant (Unpaired t-test: t=1.37, p>0.05) and the 95% confidence intervals were 529.7 – 593.9µm and 524.3 – 558.7µm respectively. Similarly, the difference in mean IOP between males (13.9 ± 3.0mmHg) and females (16.1 ± 6.8mmHg) was not significant (p>0.05) and the 95% confidence intervals were 11.8-16.0 and 12.3 – 19.9mmHg respectively. Summarily, neither CCT nor IOP were affected by gender. This was consistent with the finding of Lleo et al (28) who reported no significant difference in mean IOP between males (15.47 ± 2.21mmHg) and females (15.37 ± 2.23mmHg). A slight association between IOP and CCT was found in the myopic group but the linear regression was not statistically significant (p=0.33, ANOVA). However, the association between IOP and CCT in the hyperopic group (r=0.09, p>0.05). No linearity can be predicted between IOP and CCT. Lleo et al found a correlation between CCT and IOP (r=0.184, p<0.001). In a regression analysis, it was found that CCT was correlated linearly with increased IOP values (p<0.001, ANOVA). Tonnu and colleagues (15) found a significant association between measured IOP and central corneal thickness. The change in mIOP for a 10µm increase in CCT in myopic and hyperopic groups for the Goldmann applanation tonometer was 0.28 and 0.14mmHg respectively in this study. There was a slight association between CCT and age (r=0.22, p<0.05), although the linear regression was not statistically significant (ANOVA: F=1.14, p=0.3). This was in line with the study of Lleo and colleagues who reported a non-linear correlation between CCT and age (r=0.083, p=0.065). Nemesure et al (18) reported an inverse relationship between CCT and age. The effect of age suggests age-related corneal biomechanical changes.

In conclusion, this study has shown that there is no linear correlation between CCT and MSEM and MSEH. This means that CCT is neither affected by MSEM nor MSEH although there was an association between them. The slight association between CCT and age indicated a reduction of CCT with increasing age. The non-association between CCT and IOP shows that the mIOP cannot be recalculated to get the true IOP based on differences in CCT. It was also shown that neither CCT nor IOP was influenced by gender.

It is recommended that as from the age of 40 years and above, whatever the refractive error, the measured IOP should be considered critically on the basis of the CCT with a view to identifying those at higher risk of developing POAG. These should be combined with the cup-to-disc ratio especially when greater than 0.5, as this is in line with Ocular hypertension treatment studies.(3,5)

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