Scientific Research Publishing

Open Journal of Ophthalmology, 2023, 13, 221-232
https://www.scirp.org/journal/ojoph
ISSN Online: 2165-7416
ISSN Print: 2165-7408

The Mean Central Cornea Thickness and Associated Factors among Adult Patients Attending Mulago Hospital Eye Clinic Kampala, Uganda

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How to cite this paper: Ali, S.H., Musika, A.A., Atukunda, I., Lusobya, R.C., Mukisa, J. and Nkurunziza, E. (2023) The Mean Central Cornea Thickness and Associated Factors among Adult Patients Attending Mulago Hospital Eye Clinic Kampala, Uganda. *Open Journal of Ophthalmology*, **13**, 221-232.
https://doi.org/10.4236/ojoph.2023.132019

Received: January 24, 2023
Accepted: May 13, 2023
Published: May 16, 2023

Abstract

Background: The mean central corneal thickness (CCT) values are known to have an influence on intraocular pressure measurement and vary widely with age, sex and ethnicity. Little is known about the pattern of CCT in central Uganda. **Aim:** To determine the mean central corneal thickness and its associated factors among adult patients attending Mulago Hospital eye clinic, Kampala Uganda. **Design and Method:** A cross sectional study was done from August to October 2016 on 270 adult patients selected by systemic random sampling. The study included all adult patients who attended the eye clinic during the study period and consented to the study excluding those who had conditions causing abnormal thinning, thickening or irregularity of the cornea. The participants were evaluated by history taking and ocular examination including visual acuity assessment, slit lamp examination, central cornea thickness measurement, intraocular pressure measurement and funduscopy. Data were collected using a pretested questionnaire, entered using Epidata and analyzed by STATA11.0. **Results:** Of the 270 patients examined, 61% were female, 39% male, the mean age being 42 years ranging from 18 to 96 years. The mean central corneal thickness for both eyes was 539.3 (SD ± 41.65 μm) ranging from 332 μm to 701 μm and mean intraocular pressure was 15 (SD ± 5.34) mmHg. Gender, ethnicity, IOP, glaucoma, hypertension, diabetes, refractive error, were not statistically significantly associated with central cornea thickness. However central cornea thickness was statistically significantly associated with systolic blood pressure ($r = -0.24$, $p = 0.025$) and age ($p = 0.002$). A one-year increase in age reduced the mean central cornea

thickness by 0.54 μm. **Conclusion:** The average CCT of Ugandan adult population was 539.3 ± 41.65 μm which falls in the category of normal central cornea thickness. Central corneal thickness reduced with increasing age and increasing systolic blood pressure.

Keywords

Central Cornea Thickness, Intraocular Pressure, Fundus

1. Introduction

Central corneal thickness is one of the ocular biometric indexes used in assessing the corneal health status [1]. It provides valid information about the physiological condition of the cornea and the possible changes that the tissue may undergo during diseases, trauma and hypoxia. There has been an increasing interest in determining the values and differences in normal central corneal thickness especially now that it is known to play a vital role in refractive surgery decision like Laser in Situ keratomileusis (LASIK) and photorefractive keratectomy (PRK).

A consideration of the central corneal thickness (CCT) can have a substantial impact on the reliability of Intra Ocular Pressure (IOP) measurement as a diagnostic tool for glaucoma suspects [2]. Furthermore, the CCT data may have an influence on the clinical categorization and risk assessment of individuals with ocular hypertension ([3], low tension glaucoma [4]. Applanation tonometry (the Gold standard for IOP measurement) has been noted to be affected by Central Cornea Thickness (CCT), resulting in overestimation or underestimation of IOP measurement [5]. Small changes could be clinically significant especially in individuals predisposed to glaucoma where it may lead to late glaucoma diagnosis and more aggressive forms of glaucoma which are expensive to treat and may lead to irreversible blindness in the long term. Furthermore, failure to adjust IOP for CCT variation could lead to inappropriate targeting of IOP in management of glaucoma. Many factors postulated to influence the range of central corneal thickness values in the general population include; genetic factors, age, gender, race, blink rate, hypertension, diabetes, drugs, time of day, IOP measurement (GAT), type of measuring equipment used evidence of anterior segment pathology like corneal opacities and corneal dystrophies, previous corneal surgery, use of contact lens, epithelial Corneal edema, Corneal astigmatism (≥3D) [6] [7].

A study done at Ruharo eye center in western Uganda on glaucoma patients showed that mean CCT was 516.19 μm ± 39.95 μm among Bantu people aged 16 - 60 years old [8]. However, there was limited information about the variation of the CCT in central region of Uganda which is a metropolitan population.

We therefore carried out a cross sectional study to determine the mean CCT and factors associated with Central cornea thickness among adult patients attending Mulago Hospital eye clinic, Kampala with the hope of generating base-

line evidence for further research, improvement of clinical diagnosis and management of patients at the eye clinic.

2. Patients and Methods

This was a cross sectional study done from August to October 2016 on 270 adult patients selected by systematic random sampling. The study was carried out at Mulago hospital eye department which is the National Referral and teaching facility for Makerere University College of health Sciences situated in Kampala, central Uganda. The study included all adult patients who attended Mulago Hospital eye clinic during the study period and consented to the study. We excluded participants with conditions that cause abnormal thinning, thickening or irregularity of the cornea because they lead to decrease or increase in CCT values thus affecting the accuracy of CCT/IOP measurement. These conditions included: evidence of anterior segment pathology like corneal opacities, corneal ulcers; collagen disorders (including keratoconus), endothelial-based corneal dystrophies (e.g., Fuchs), previous corneal surgery involving Central cornea, previous cornea trauma/injury, previous refractive surgery, corneal edema, corneal astigmatism (≥3.00 D) and contact lens wear.

The participants had a standardized interview about any previous or current condition as follows:

Demographic characteristics include age, sex, and ethnicity. Medical history included history of chronic disease *i.e.* hypertension, diabetics that may influence CCT measurement. Ocular history including history of glaucoma, previous ocular trauma or ocular surgery. Blood pressure was measured using a manual sphygmomanometer and Random blood sugar was measured using a glucometer. All participants underwent bilateral standard ophthalmic examination which included measurement of visual acuity, Refraction, slit-lamp microscopic examination, measurement of IOP and CCT, fundoscopy and visual field.

The central corneal thickness was assessed with the ultrasound pachymeter (Compact Touch: 3 in 1 Ultrasound System) after applying tetracaine Hcl 0.1% to the eye. The probe was disinfected with an alcohol swab. The subject sit on the chair and was asked to fixate on a distant target, while the ultrasound probe was aligned perpendicular to the center of the cornea and placed gently in contact with the cornea. A set of five measurements were taken on each eye and average readings were recorded in microns (μm). The probe was disinfected between the examinations of the two eyes and also between the participants for infection control. Central cornea thickness values ranging from 505 μm to 567 μm were considered as normal. Below 505 μm were considered as thin cornea and those with a central cornea value above 567 μm were considered as thick cornea.

The IOP was assessed with the Slit-lamp, Goldmann applanation tonometer after disinfecting the tonometer prism with hydrogen peroxide and applied tetracaine Hcl 0.1% and stained the eye with wetted fluorescein strip. Three consecutive readings were taken and the average was recorded as measured IOP in

mmHg. There was an interval of 10 minutes between CCT measurements and IOP to minimize possible confounding factors. Both CCT and IOP measurements were taken from 9 am to 12 noon by principal investigator to avoid diurnal variation. Dilation of the pupil was done using tropicamide eye drops and dilated fundus assessment using slitlamp biomicroscopy with 90D or 78D lens. The posterior segment was examined; lens vitreous and retina (optic disc, vessels, macula and peripheral retina). Visual field (using oculus twin field perimetry) was also done.

Data entry was done using Epidata 3.1 and analysis was by STATA 11.0. Continuous variables were summarized using means, standard deviations, medians, and ranges. Categorical variables were summarized using frequencies, proportions, and percentages, Graphs and charts. Bivariate analysis (simple linear regression & Correlations) and multivariate analysis (multiple linear regression model) was done. Factors were considered to be statistically significantly associated with CCT if p value was ≤0.05.

3. Results

3.1. Baseline Characteristics of Study Participants

A total of 270 adults aged attending Mulago Hospital eye clinic were recruited between August to October 2016. From Table 1 below, the majority of the patients (37%) were of age between 35 to 50 (middle aged) followed by those 35 years and below (34%). About 61% were females and39% were males.

The majority, 81% participants were Bantu followed by 12% Nilotics, 5% Nilo-hamites and 2% others. Among the 270 participants, 4% (12) were known glaucoma patients, 9% (25) were Diabetic and 20% (53) had Hypertension.

3.2. Mean Central Cornea Thickness among Adult Patients

CCT measurements were taken for the right and the left eye separately. Subsequently the mean CCT of the right eye, left eye and both eyes was determined. The mean (SD) CCT measurements were 537.06 ± 53.29 (Right eye), 541.61 ± 42.69 micrometers (Left eye) and 539.28 ± 41.65 for both eyes (Table 2). The minimum CCT was 332 µm while the maximum CCT was 701 µm. The two means were not so significantly different.

As displayed in Table 3, young adults aged 18-35 years had a higher mean CCT (540.9 µm) compared to the older age group of >35 - 50 years (538.4 µm) ($p = 0.023$) and this was statistically significant. Male participants had slightly higher mean CCT (541.2 µm) compared to the females (537.3 µm) but this was not statistically significant ($p = 0.48$). Bantu who were the majority of the study participants had thinner CCTs compared to the nilotics and nilo-hamites however, this was not found statistically significant.

From Table 4, majority of the factors (age, gender, ethnicity, glaucoma absence, normal pressure, hypertension, random blood sugar > 200 mg/dL, refractive error, abnormal conjunctiva, abnormal lens, and abnormal vitreous, abnor-

mal CDR, abnormal visual fields had a negative relationship with the mean CCT but this was only statistically significant with age (p = 0.012), abnormal CDR (p = 0.0016) and abnormal visual fields (p = 0.044).

Table 1. Baseline characteristics of the participants (N = 270).

Variables	Frequency (N = 270)	Percentage (%)
Age		
18 - 35 yrs	91	34
>35 - 50 yrs	100	37
>50 yrs	79	29
Gender		
Male	106	39
Female	164	61
Ethnic group		
Bantu	219	81
Nilotics	33	12
Nilohamites	14	5
Others	4	2
Diabetics		
Yes (RBS ≥ 200)	25	9
No (RBS < 200)	245	91
Glaucoma		
Yes	12	4
No	159	59
Not sure	99	37
Hypertensive (mmHg)		
Yes (140/90)	53	20
No (120/80)	217	80
History of eye trauma		
Yes	23	9
No	247	91
History of surgical operation on eye		
Yes	32	12
No	238	88

Table 2. Mean central cornea thickness among adult patients.

Variable	CCT Right eye	CCT left eye	Mean CCT both eyes
Mean ± SD	537.06 ± 53.29	541.61 ± 42.69	539.28 ± 41.65
Minimum, Maximum	353, 701	443, 777	332, 701

Table 3. Distribution of mean CCT of both eyes by age, gender and ethnic group.

Variable	Mean CCT	Standard deviation	p-value
Age			
18 - 35 yrs	540.9	73.13	**0.012**
>35 - 50 yrs	538.4	41.76	**0.023**
>50 yrs	530.9	36.76	
Gender			
Male	541.2	36.66	
Female	537.3	44.44	0.438
Ethnic group			
Bantu	538.4	43.10	
Nilotics	542.9	36.56	0.205
Nilo-hamites	544.5	31.78	0.56
Others	537.3	40.55	0.664

Table 4. Factors associated with the mean central cornea thickness.

Factor	β Coefficient	p-value
Age	−0.43	**0.012***
Gender, (male)		
Female	−4.08	0.438
Ethnicity, (Others)		
Bantu	−4.84	0.646
Nilotics	−0.36	0.977
Glaucoma, (no)		
Yes	−0.09	0.996
Not sure	2.00	0.708
History of eye trauma, (no)		
Yes	−4.59	0.614
History of surgical operation on eye, (no)		
Yes	−9.39	0.238
Blood pressure (mmHg), Hypotension		
Normal	−7.64	0.329
Hypertension	−15.54	0.067
Random blood sugar (mg/dL) (<200)		
≥200	−3.02	0.787
Visual acuity, Normal **(6/6)**		
Abnormal	−1.60	0.796
Intraocular pressure (mmhg)	0.69	0.145

Continued

Refractive Error, (Normal)		
Myopia	−9.55	0.252
Hypermetropia	−15.77	0.403
Eyelids, (Normal)		
Abnormal	15.56	0.599
Conjunctiva, (Normal)		
Abnormal	−4.42	0.566
Lens, (Normal)		
Abnormal	−3.94	0.557
Vitreous, (Normal)		
Abnormal	−20.45	0.244
Fundus: DISC CDR, (Normal)		
Abnormal	−35.77	**0.016***
Anterior chamber, (Normal)		
Abnormal	1.48	0.917
Visual field, (Normal)		
Abnormal	−26.99	**0.044***

The factors which had statistically significant relationship with mean CCT (p-value ≤ 0.05) were considered for multivariate analysis.

3.3. Factors Associated with the Mean Central Cornea Thickness

CT and Age

There was a negative low correlation between the CCT and age of the participants which was statistically significant (r = −0.1527, p = 0.012), Figure 1.

There was a statistically significant negative correlation between CCT and systolic blood pressure (r = −0.24, p = 0.025), Figure 2.

In our final model of multivariate analysis, age, abnormal fundus CDR and abnormal visual field were found to be negatively associated with mean CCT but this relationship was statistically significant only with age (p = 0.002). This meant that the mean CCT was reduced by 0.54 μm for every unit increase in age by year (Table 5).

4. Discussion

In our study, the mean central corneal thickness for both eyes was 539.3 ± 41.65 μm ranging from 332 to 701 μm. This finding is almost similar to that in the study done in Nigeria 537 μm ± 38.4 (CI 532.1 - 543.7) [9]. In our study, both glaucoma and non-glaucoma patients had mean CCT of 539.3 ± 41.65 μm, this value was different in the Ruharo study (south-western Uganda) where the CCT was 516.19 ± 39.95 μm [10] and in the Ethiopian study with 508.07 μm [7] where

Table 5. Multivariate factors associated with the mean central cornea thickness.

Factor	R-Squared	β Coefficient	p-value
Age	**0.050**	−0.54	**0.002**
Fundus: DISC CDR, (Normal)			
Abnormal		−4.56	0.677
Visual field (Normal)			
Abnormal		−16.15	0.325

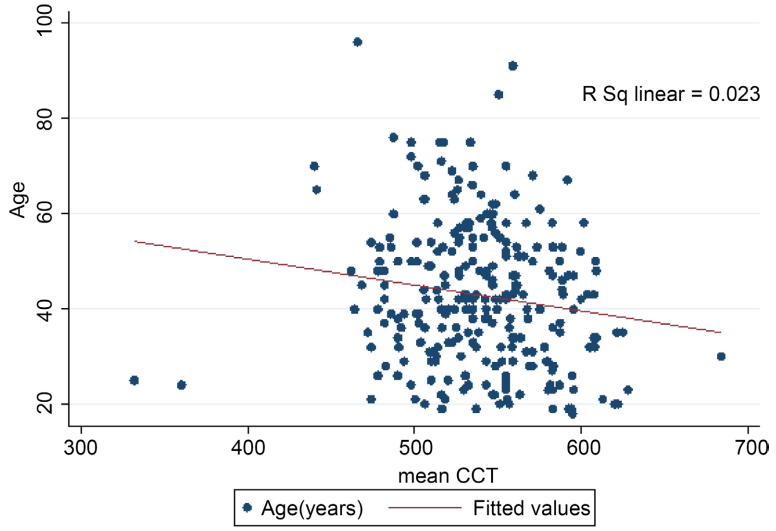

Figure 1. Relationship between central cornea thickness and age.

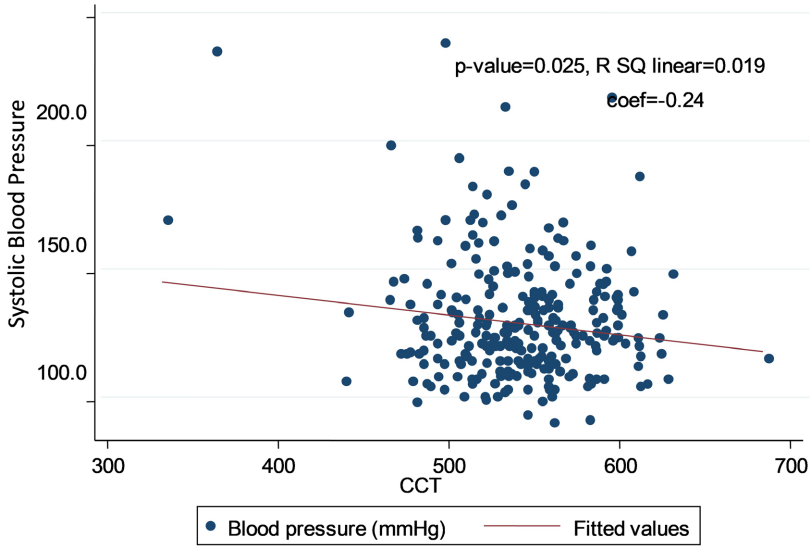

Figure 2. Scatter plot demonstrating the correlation between CCT and systolic blood pressure.

the study population was glaucoma patients, in whom glaucoma could be contributing to the corneal thinning.

The obtained mean CCT (539.3 ± 41.65 μm) value, compares well among the

African population such as the study done in Sudan where Mean CCT was 530.2 ± 58.1 μm [11] and African American (535.46 ± 33.39 μm) [12]. However, it is slightly higher than that in Kenya, 521.43 μm micrometers [13] and in Cameroon, 529.29 ± 35.9 μm [14]. Aghaian *et al.*, studied the corneal thickness by ultrasonic pachymeter in an ethnically diverse population and found that the mean CCT of whites was (550.4 μm) and Hispanics (548.1 μm). Among the Asian subpopulations, Japanese participants had the thinnest CCT (531.7 μm) compared to the Chinese (555.6 μm) and Filipino (550.6 μm) subjects [15].

Age was statistically significantly associated with mean central cornea thickness. A one year increase in age reduces the mean central cornea thickness by 0.54 ($p = 0.002$) and this negative relationship was similar to the findings reported in the Cameroon [14] and Mongolian populations [16] studies which showed reduction in CCT with increasing age between 2 - 8 μm per decade. This finding supports the fact that CCT decreases over the lifetime, meaning that older people have thinner corneas because of ultra-structural changes in the collagen fibrils of the cornea. Based on histological studies, the corneas of older people are thinner because of a reduction in keratocyte density and possible destruction of collagen fibers, and older individuals are exposed to environmental factors for a longer period of time, which might influence corneal structure [17].

Our study showed a negative relationship between CCT and systemic hypertension ($p = 0.067$) in multivariate analysis, but with a statistically significant correlation ($r = -0.24$, $p = 0.025$) between the CCT and systolic blood pressure. This result was in contrast to the Namil study which found a significant association between the presence of systemic hypertension and a thinner central cornea ($p = 0.027$), which suggests that hypertension per se or blood pressure-lowering medication may affect CCT [18] but the underlying mechanism remains unclear.

Our study showed that both abnormal visual field ($p = 0.325$) and abnormal fundus CDR ($p = 0.677$) had negative relationship to the CCT but this was not statistically significant. These results are comparable to some studies which had not proved the association between changes in the fields of vision on the corneal thickness [19]. Central corneal thickness correlated significantly with abnormal CDR ratio and the loss of visual field [20] [21] but the rate of progression varied in different studies. In some studies, eyes with early visual field defect had greater CCT than those with severe visual field defect [22] [23] while others reported no difference in early or late visual field defect.

Our study had some limitations. The study was hospital based and thus the participants may not be accurate representatives of whole population. Since this study was cross sectional, it was difficult to examine causality among the participants. Furthermore, although in the analysis confounding was minimized by use of regression modelling techniques, this study may have residual confounding by unmeasured variables.

5. Conclusion

The average CCT of our study population was 539.3 ± 41.65 μm which lies in the

range of normal corneal thickness. Males had a higher CCT than females. Age was negatively associated with CCT. Although hypertension was not associated with CCT ($p = 0.067$) there was statistically correlation between CCT and systolic blood pressure ($r = -0.24$, $p = 0.025$). There was no statistically significant relationship between CCT and IOP, sex, refractive error, DM and visual field defect. There is need for wider studies preferably population based to establish the population mean CCT and determine the factors associated with the CCT and variation of IOP with CCT.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgements

We are grateful to all the study participants who took off time to participate in the study. A vote of thanks to all the ophthalmologists for the tremendous knowledge and support accorded to this research project.

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