CENTRAL CORNEAL THICKNESS AND INTRAOCULAR PRESSURE IN KENYA

A DISSERTATION PRESENTED IN PART FULFILLMENT FOR THE DEGREE OF MASTER OF MEDICINE (OPHTHALMOLOGY) UNIVERSITY OF NAIROBI

BY:

DR. EDWARD M. WAFULA
MBChB (NAIROBI)
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DECLARATION

This thesis is my original work and has not been presented for a degree at any other university

SIGNED: _____ Date: 16/7/06.

DR. EDWARD M. WAFULA

APPROVAL

This dissertation has been submitted in part fulfillment for the degree of Masters of Medicine (Ophthalmology) with our approval as University Supervisors.

1. Signed ..... Date 10/07/06

Dr. Martin Kollmann
MBChB(Goettingen), MD(Goettingen), MMed.Ophthal(Munich),
D.Trop.Med&Med.Parasitol (Hamburg)
Senior Lecturer,
Department of Ophthalmology
University of Nairobi.

2. Signed ..... Date 11/07/06

Dr. Dunera Rahel Ilako
MBChB, M.Med. Ophthal. (Nairobi)
Senior Lecturer,
Department of Ophthalmology
University of Nairobi.

TABLE OF CONTENTS: **PAGE**

LIST OF FIGURES AND TABLES **PAGE**

Abbreviations

(1) CCT = Central corneal thickness

(2) CDR =Cup / Disc Ratio

(3) GAT = Goldmann Applanation Tonometry

(4) ICC = Intra-class evaluation coefficient

(5) IOP = Intraocular Pressure

(6) LE = Left Eye

(7) OHTS = Ocular Hypertension Treatment Study

(8) POAG =Primary open angle glaucoma

(9) RE = Right Eye

(10) SIT = Schioetz Indentation Tonometry

(11) USA = United States of America

(12) N = Sample Size

(13) SD = Standard Deviation

ABSTRACT

Title: Central Corneal thickness and intraocular pressures in Kenya.

Objective: The main objective of this study was to establish the central corneal thickness in selected Kenyan communities.

Rationale : Studies done in Caucasians and African Americans suggest that Africans have thinner central corneas and this leads to an underestimation of intraocular pressures. Hence patients may end up not receiving appropriate treatment with subsequent glaucomatous damage and loss of vision that might have been avoidable.

Statement of the Problem:

Intraocular pressure is an essential element in the management of glaucoma. CCT has been identified as a potential source of error in the measurement of IOP [1-2].

Estimates of intraocular pressure by applanation tonometry are influenced by CCT. We assume and apply a specific value for CCT in applanation tonometry estimates as the Goldmann equation is based on theoretical calculations accurate at CCT of 520 micrometers. However, there is compelling evidence that CCT varies between individuals, with ethnicity.

Failure to adjust IOP estimates of variation in CCT influences clinical decision-making. The underestimation of IOP due to thin cornea may delay the diagnosis and treatment of glaucoma. There is also the risk of pseudo-ocular hypertensive patients being subjected to inappropriate treatment in cases of thicker CCT [3]

The measurement of CCT may play a role in the clinical evaluation of IOP with a baseline CCT to be obtained for patients with suspected glaucoma. The American Academy of Ophthalmology [1] reports that this recommendation presents Ophthalmologists with a dilemma: there is no single formula to recalculate IOP as the relationship between CCT and IOP is not linear and there is no accepted universal algorithm [2, 25].

Methodology: A total of 261 eyes of 132 patients were examined. Three patients had only one eye included in the study as their contralateral eyes had corneal pathologies.

Three hospitals with eye units were selected representing three major ethnic groups in Kenya: that is Sabatia Hospital, Litein AIC Mission Hospital and Isiolo District Hospital - had their Central Corneal Thickness, Goldmann Applanation Tonometry and Schioetz Indentation Tonometry readings where applicable.

Results: A total of 261 eyes of 132 patients were analyzed for CCT, GAT and SIT. There were 71 males (54%) and 61 female (46%) respectively.

Bantus contributed 143, Nilotes 90 and Cushites 28. Using Levene's Test for Equality of Variance, P was 0.013 at a mean difference of $\pm$ 15.54. This is statistically insignificant and variation in sample numbers did not affect the final results of CCT, GAT and SIT.

The mean CCT was 521.43 micrometers, with a GAT mean of 15.04mmHg and a SIT mean of 14.393mmHg. This mean CCT of 521.43 micrometers is lower than that established by other studies of 555-573 micrometers. [3, 9, 20, 35, 38, 41, 42, 44]. The mean CCT for the three ethnic groups were 521.76, 524.72 and 509.18 micrometers respectively. Weighted t-test correlations showed no statistical significance.

Conclusion: This study established that Kenyans from the sampled communities representing major sections of the Kenyan population) have significantly lower CCTs as established in previous studies from West Africa and USA on African-Americans.

It is imperative that Kenyan patients with established or suspected glaucoma but low IOPs undergo CCT measurements to establish any effect of their CCT on IOP readings [22, 32]. This will necessitate individualising pressure target for these patients to prevent any glaucomatous damage.

1. INTRODUCTION AND LITERATURE REVIEW

Pachymetry is a widely used technique in determining corneal thickness. [1] It utilizes the recording of a time difference between a reflection from the anterior and posterior corneal surfaces. Studies have shown high intraobserver and interobserver reproducibility. [14] Both ultrasonic and optical pachymetry are methods of measuring corneal thickness. While ultrasonic pachymetry is more reproducible, optical pachymetry is especially helpful in measuring the depth of corneal pathology. [8] Pachymetry is not a new technology; it has been used in routine ophthalmologic conditions such as: [2, 3, 19, 20, 25]

- Corneal oedema
- Corneal dystrophy affecting the endothelium
- Fuchs's corneal dystrophy
- Corneal transplant rejection
- Sequential corneal pachymetry used to document the resolution of post operative corneal oedema
- Compromised endothelial function before cataract surgery
- In patients diagnosed with glaucoma or elevated intraocular pressure (>24mm hg), baseline CCT testing is considered necessary

Ultrasonic pachymeters are designed for measuring the axial length of the eye as well as the thickness of the cornea. Ultrasound energy is emitted from the probe tip acting as both the transmitter and receiver. Some of the energy is reflected back towards the probe in the form of an echo. [14] Measurement data can be calculated based on both the time it takes the echo to travel back to the probe from the eye and the preset converted velocity.

In a comparative study Sallet, et al.,compared CCT measured by optical pachymetry to results obtained by ultrasound on 100 eyes. Optical pachymetry was performed using the non-contact, specular microscope and three measurements were averaged followed by the installation of a topical anaesthetic.

The next three measurements were taken using the ultrasound pachymeter. The authors concluded that optical and ultrasound pachymetry results are comparable.

LaRosa et. al. reported a comparative study of CCT in Caucasians and African Americans in glaucomatous and non-glaucomatous populations. A statistically significant difference was found between the CCT of African-Americans and Caucasians with suspected or confirmed glaucoma and control populations of African-Americas and Caucasian subjects with no evidence of glaucoma, elevated intraocular pressure or optic nerve damage. This study raises the possibility that individual CCT may need to be taken into account to accurately assess the IOP for the diagnosis and management of glaucoma[3].

Results from the Ocular Hypertension Treatment Study (OHTS) that CCT is related to race. The authors selected 1301 patients with ocular hypertension (IOP of ≥24mm hg). CCT was determined by ultrasonic pachymetry (same make and model in all sites). The mean CCT was 573.0±39.0μm.The mean CCT for African American subjects (555.7±40.0μm; n=318) was 23μm thinner than for Caucasian subjects. The authors concluded that the effect of CCT may influence the accuracy of applanation tonometry influencing the diagnosis and management of patients with glaucoma and ocular hypertension[2, 25].

Studies using orbscan and ultrasound pachymetry have demonstrated high indices of intra-observer and inter-observer reproducibility of results in CCT measurements. Intra-class evaluation co-efficient (ICC) on readings taken on 51 volunteers showed coefficient ranges of 0.95-0.99 and 0.89–0.95 respectively with a variability of ≤ ± 1% to ≤ ± 2%. Hence these pachymetres have high accuracy.[21, 28, 30, 31]

Ventura et al postulated that patients with ocular hypertension have thicker CCT than those with normotensive glaucoma. They compared 34 normotensive patients, 20 patients with POAG and 12 patients with ocular hypertension and concluded that CCT was significantly higher ($P \leq 0.003$) in patients with ocular hypertension. Similar results have been reproduced elsewhere.[6]

Orbscan pachymetry has also been used to measure corneal thickness in volunteers with normal eyes. Mapping has shown that the thinnest section is cantered 0.90mm from the visual axis with an average value of 0.55 mm. The central cornea has the lowest thickness of 0.56 mm ± 0.03 mm and the superior cornea is thickest with average values of 0.64 ± 0.003.[9,20]

However, patients with a history of intraocular operations, for example cataract surgery, may give higher readings due to endothelial cell loss with subsequently altered hydration (Na^+ - K^+ ATPase activity deficit).[10, 11, 29] Thus patients below the critical corneal endothelial cell density of 400-500 cells/sqmm should be evaluated carefully. The pre-operative CCT of 30 patients with readings of 537 ± 27mm increased to 621 ± 9.54 mm on the 1st post-operative day. However, normal CCT may be regained to within physiological values after three months postoperatively.

Several studies have suggested an increase of 0.014 – 0.179 mmHg /0.01 mm increase in CCT. This can significantly precipitate glaucomatous changes in predisposed (threshold) patients. This correlates to results from a study by Ehlers et al with a suggested relation of 0.011 – 0.071mmHg/0.01mm CCT increase.[16, 28]

Intraocular pressure is an essential element in diagnosing and managing glaucoma and Goldman applanation tonometry is the gold standard for its clinical measurement. However, CCT has been established as a potential source of error as the underlying Goldman equation is based on a CCT of 520µm. Measurement of individual central CCT may evolve to play a role in the clinical measurement of IOP with a baseline CCT needed for all patients with glaucoma or glaucoma suspects. However, the American Academy of Ophthalmology[1] reports that this recommendation to factor CCT into the IOP reading presents ophthalmologists with a dilemma because there is no single formula that recalculates IOP as the relationship between CCT and IOP is not linear and there is no currently accepted universal algorithm.[2,25]

There is evidence that CCT as a factor in the measurement of IOP varies among races and shows a diurnal pattern [39, 43, 44]. However, there is insufficient data available from African communities and no data from Kenya. Gender, age and the presence of pseudo-exfoliation and has a diurnal variation. Studies have suggested an increase of 0.014-0.179 mmHg /0.01 mm with increase in CCT. This can significantly precipitate glaucomatous changes in predisposed (threshold) patients [4, 6].

2. RATIONALE

Studies done in Caucasians and African-Americans suggest that blacks have thinner corneas than whites and this leads to intra-ocular pressure under-estimation in blacks. [2, 16, 25, 28, 31, 39, 41]

Studies in West-African communities confirm these findings. This study endeavoured to establish CCT in selected Kenyan communities. No such study has been done in the East African region.

3. AIMS

The aims of this study were:

1. To assess CCT in Kenyans comparing results with findings from other populations.

2. To asses the general pattern of IOP in Kenyans by different techniques and compare established ranges and CCT.

4. OBJECTIVES

The objectives of this study were:

1. To establish CCT for Kenya in selected Kenyan communities.

2. To establish the distribution of IOP readings taken by Goldmann applanation and Schioetz indentation tonometry in selected Kenyan communities.

3. To compare CCT among selected Kenyan communities.

4. To relate IOP and CCT readings.

5. METHODOLOGY

The study was carried out in the eye units of the three selected hospitals that is Sabatia Hospital. Litein AIC Hospital and Isiolo District Hospital. These three hospital eye units are located in areas that have a generally presumed the heartland of Luhyas, Kipsigis, and Somalis respectively, with relatively authentic populations.

Patients were filtered by the out patient nurse and only those between the age of 15-55 years were directed to the study examination room. This age group was selected as they have a stable endothelial cell counts hence less variability in corneal thickness.

Ocular history plus systemic history was taken. This included recent ocular surgeries, medications (both ocular and systemic) and any known ocular diseases. Other recorded patient's data included age, gender and ethnicity (Appendix I).

Recruited patients had a detailed slitlamp examination of their anterior segment to rule out corneal pathology.

The aim of the study was explained to all eligible patients including potential side effects of local anaesthetic and fluorescene eye drops. A written informed consent was obtained thereafter.

Consenting patients had:

(a). One drop of 0.5% Amethocaine installed in both eyes. After 40 to 60 seconds CCT measurements was taken using the Ocuscan RxP contact pachymeter (model number 8065750127). Two pachymeter readings where taken and the average was recorded in a prepared chart.

(b). After a further 60 seconds IOP was measured with Goldmann Applanation Tonometry 2 readings after fluorescene staining and average recorded in a prepared chart (appendix1).

(c). After another1-2 minutes Schioetz Tonometry was taken and IOP recorded in a prepared chart.

(d). Patients who need posterior segment examination were dilated with Tropicamide eye drops and funduscopy done.

(e). Patients with ocular pathologies were referred to an ophthalmologist for further management.

(f).CCT and IOPs were also recorded in the patients' outpatients' card of the respective eye units for further references and as a benefit to the patients care.

Sabatia Eye hospital had a functional Goldmann Applanation Tonometer and Schioetz Indentation Tonometer. Hence all patients in Sabatia had corneal thickness, applanation and indentation tonometry readings taken.

Litein AIC Mission Hospital did not have an operational Goldmann Applanation Tonometer. Hence only corneal thickness and Schioetz Tonometry measurement could be taken.

Patients in Isiolo District Hospital underwent only central corneal thickness measurement as Goldmann Applanation and Schioetz Tonometry were non-functional at the time of the study.

5.1 Study Design

Cross-sectional study (among selected communities).

5.2 Sample Size:

261 eyes were examined. This is in line with patients' attendance in the selected eye units and age distribution. No statistical formula was applied due to this being a cross sectional study. All patients who met inclusion criteria participated in the study.

5.3 Data analysis

Quantitative data was analyzed and processed using SPSS version 11 statistical software. Results are presented using ratios, proportions, rates, tables and diagrams wherever appropriate. Statistical significance testing was carried out whenever appropriate and level of significance was taken at 95%.

5.4 Data storage

Confidentiality was maintained throughout the study.

5.5 Study Area

Reflecting the selected communities with predominant different ethnic backgrounds, the following peripheral eye units were selected:

1. Litein AIC Hospital: predominantly Kipsigis (Nilotes)
2. Sabatia Eye Hospital: predominantly Luhyas (Bantus)
3. Isiolo District Hospital: predominantly Somalis (Cushites)

5.6 Study Period

A period of three weeks from 20th June and 8th July 2005, with one week for each unit.

5.7 Ethical considerations

1) Patients' clinic and treatment records were kept in confidentiality. Data entry did not include patients' names.
2) Informed and written consent was mandatory for inclusion in the study.
3) Amethocaine 0.5% eye drops is lawfully registered for use as local anaesthetic in Kenya.
4) Patients who had any ocular disease were treated and / or referred for further management.

5.8 Inclusion Criteria

All consenting patients between the age of 15-55 years who had no pathology of the cornea and sclera.

This age group is known to have stable CCT without significant effects of aging. [38, 39, 43]. Furthermore participants in this age group are expected to be sufficiently understanding and cooperative for accurate readings of CCT and IOP measurements.

5.9 Exclusion Criteria

1. Patients who were not willing to participate in the study.
2. Patients who had significant corneal and / or scleral pathology
3 Patients with recent intra-ocular surgeries, ocular hypertension or glaucoma. These are conditions that potentially affect CCT and IOP. [35, 36,38] Recent intra-ocular surgery was defined as within the last 4-6 months. These were mainly cataract extraction and glaucoma filtration surgeries.

5.10 Materials and Equipment

1. Ocuscan RxP Pachymetry
2. Goldmann's Applanation Tonometer
3. Schioetz Indentation Tonometer
4. Fluorescein eye strips
5. Tetracaine eye drops
6. Slitlamp (indicate model for each station)
7. Volk 90 D Loup
8. Heine indirect ophthalmoscope (sigma 150) with Volk 20 D Loup

5.11 Study Limitations

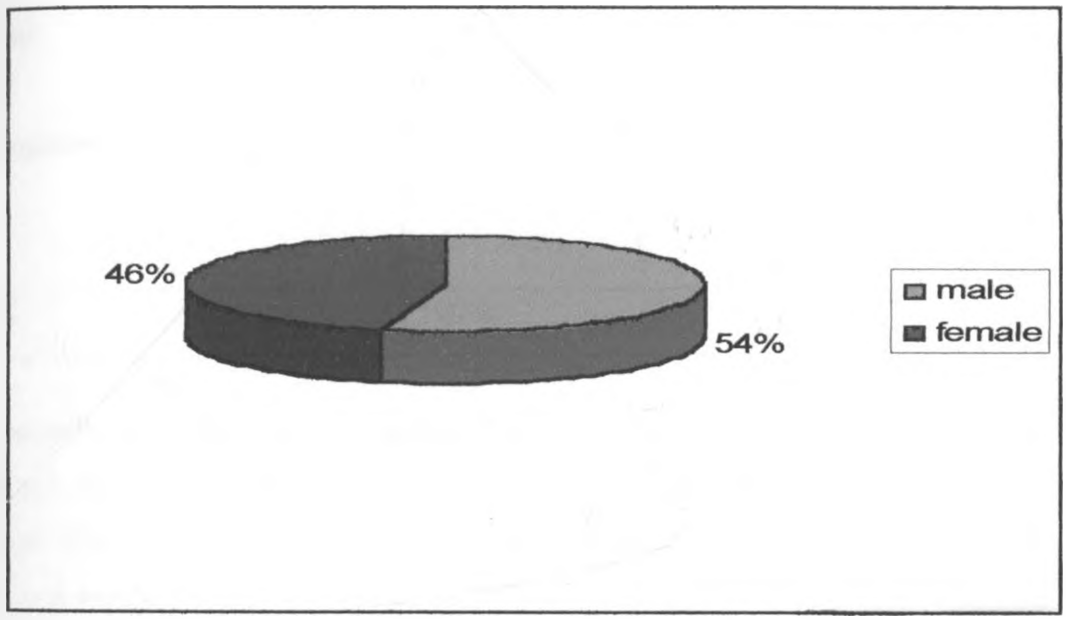
1. Deviating from previously obtained information two of the selected eye units were found to have incomplete operational equipment on arrival. This contributed to the significant variance in sample size for some study variables:
   a) Isiolo District Hospital eye unit had no Goldmann Applanation Tonometer and no operational Schioetz Indentation Tonometer. Hence, only CCT readings were taken.
   b) Litein AIC Mission Hospital eye unit had no operational Goldmann Applanation Tonometer. Hence, only CCT and Schioetz Indentation Tonometry measurements were taken.
2. Uncertainty about mixed ethnicity , however they identified core areas of tribes are considered sufficiently representative
3. Lack of calibration of Goldmann applannation tonometres.
4. The study was done on eye patients eventhough we excluded relevant corneal pathologies.

6. RESULTS

Participants were recruited from the eye clinics of Sabatia Eye Hospital, Litein AIC Mission Hospital and Isiolo District Hospital. Demographic data included sex, age and ethnicity, and were recorded on a pre-prepared biodata sheet. The following are the computed results of the study.

6.1 Gender

FIGURE 1: GENDER DISTRIBUTION OF PATIENTS (N = 132 patients)



A total of 261 eyes of 132 patients were included in the study. There were 71 males (54%) and 61 females (46%) respectively.

6.2 Age

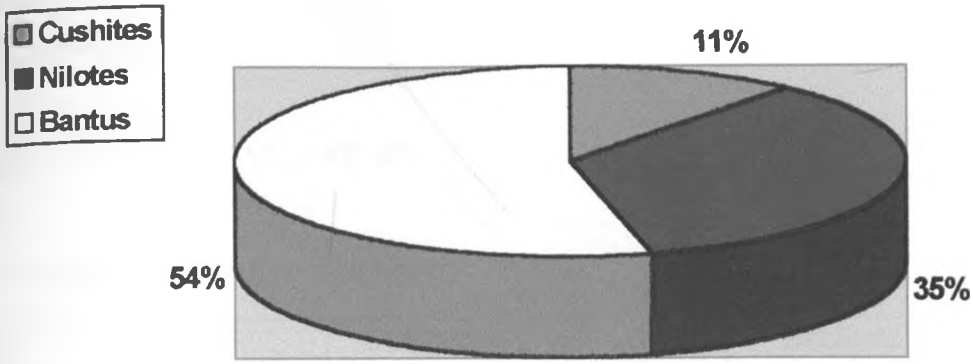
TABLE 1: AGE DISTRIBUTION OF PATIENTS (N=132 patients)

AGE (years)	Frequency	Percentage	Valid percentage	Accumulative percentage
15 to 20	42	31.8	32.6	32.6
21 – 25	20	15.2	15.5	48.1
26 – 30	12	9.1	9.3	57.4
31 – 35	20	15.2	15.5	72.9
36 – 40	12	9.1	9.3	82.2
>40	23	17.4	17.8	100.0
Missing system	3	2.3		
Total	132	100.0		

The majority of patients were in the age group of 15 to 20 years (38%). Three patients had no valid age information and hence were entered as missing system. The age ranged from 15 to 55 years.The median age was 26.0 years with a mode of 18.0 years and a mean age of 29.34 years at a standard deviation (SD) of ±11.095.

6.3 Ethnicity

FIGURE 2: DISTRIBUTION OF COMMUNITIES (N = 132 patients)



The majority of patients were Bantus (Luhyas) constituting 54%, followed by Nilotes (Kalenjins) at 35% and Cushites (Somalis / Boranas) constituting 11%.

6.4 CCT

TABLE 2: CENTRAL CORNEAL THICKNESS (N = 261 eyes)

	CCT (μm)
N-valid	261
Mean	521.43
Std. Error of Mean	1.927
Median	522.00
Std. Deviation	31.124
Variance	968.685
Range	185
Minimum	446
Maximum	631

261 eyes were included in analysis. The minimum CCT was 446.00 micrometers with a maximum CCT reading of 631.00 micrometers. The mean CCT for all subjects combined was 521.434 micrometers at a standard deviation of 31.124 micrometers and a median of 522.004 micrometers.

6.5 Tonometry

A total of 121 eyes were included in the analysis with a mean Goldmann applanation tonometry of 15.04 mmHg and a median of 16.00mmHg. Minimum reading was 8mmHg and a maximum reading of 22.0mmHg

TABLE 3: IOP BY GAT AND SIT

6.5.1 Schioetz Indentation Tonometry (N=184)

	Goldmann Applanation Tonometry(mmHg)	Schioetz Indentation Tonometry (mmHg)
N-valid	121	184
Mean	15.04	14.393
Std. Error of Mean	0.251	0.1868
Median	16.00	14.600
Std. Deviation	2.758	2.5335
Variance	7.607	6.4185
Range	14	14.2
Minimum	8	10.2
Maximum	22	24.4

A total of 184 eyes were analysed. The minimum SIT measurement was 10.2 mmHg with a maximum reading of 24.4 mmHg. The mean was 14.60 mmHg at a standard deviation of ±2.5335 mmHg

6.5.2 Goldmann Applanation Tonometry (N=121)

A total of 121 eyes were analysed. The GAT was 8mmHg and a maximum of 22mmHg. The mean GAT was 15.04mmHg at SD of ± 2.758.

6.6 Central Corneal Thickness and Ethnicity

TABLE 4: CCT and Ethnical Background

Ethnicity	Mean CCT	SD
Cushites (N=28)	509.18	28.438
Nilotes (N=90)	524.72	28.623
Bantus (N=143)	521.76	32.708

The mean CCT differed between the three ethnic groups studied: Bantus had a mean CCT of 521.764 micrometers compared to Nilotes with 524.724 micrometers and Cushites with 509.184 micrometers.

6.6.1 Grouped T-Test

TABLE 5: CCT AND ETHICITY (WEIGHTED T-TEST VALUES)

Ethnicity	**N (eyes)**	**Mean**	**P Value**
Nilotes	90	524.72	0.013
Cushites	28	509.18	
Nilotes	90	524.72	0.48
Bantus	143	521.76	
Cushites	28	509.18	0.059
Bantus	143	521.76	

Using a confidence level of 95% ($p \leq 0.05$) the different ethnic groups were paired and analysed by grouped T-Tests statistical method. By correction Nilotes and Bantus had a value of $T = 0.48$. This is statistically insignificant. The same applies for CCT differences between Cushites and Bantus, $T=0.059$ ($p \leq 0.05$).

6.7 Tonometry and Ethnicity

TABLE 6: TONOMETRY AND ETHNICAL BACKGOUND

Ethnicity	GAT (mmHg)	N	SD	SIT (mmHg)	N	SD
Cushites	N/A	N/A	N/A	N/A		
Nilotes	14.54	13	2.222	15.078	85	2.5600
Bantus	15.10	108	2.818	13.805	99	5.612

Cushites were not included in this assessment as Isiolo District Hospital eye unit had neither functional applanation nor indentation tonometers.

6.7.1 Goldmann Applanation Tonometry

Nilotes had a mean GAT of 14.54mmHg compared to Bantus with a mean GAT of 15.10mmHg.

6.7.2 Schioetz Indentation Tonometry

Bantus recorded a mean SIT value of 13.805 mmHg compared to slightly higher reading of 15.078 mmHg for Nilotes.

6.8 Correlation between CCT, GAT and SIT

TABLE 7: PEARSON CORRELATION SIGNIFICANCE (2-TAILED)

	GAT (mmHG)	SIT (mmHG)	CCT (μm)
GAT Pearson correlation (2-tailed)	1 121	501 104	0.292 121
SIT Pearson correlation (2-tailed)	501 104	1 184	0.085 183
CCT Pearson correlation (2-tailed)	0.292 121	0.085 183	1 261

Pearson correlation significance (2-tailed): based on coefficient of correlation (R), the relationship between CCT and GAT was positively associated with R=0.292 (29.2%). However there is no significant correlation between CCT and SIT (R=0.085)

6.9 Comparing Right Eyes and left Eyes

TABLE 8: PAIRED ANALYSIS BETWEEN RIGHT AND LEFT EYES

	N	Mean	Median	95% CI	Paired T-tests
CCT					
Left Eye	132	520.51	522.00	511.22-529.80	0.88
Right Eye	129	520.12	520.00	509.32-530.91	
GAT					
Left Eye	61	15.25	16.00	14.56-15.95	0.716
Right Eye	60	15.33	16.00	14.57-16.10	
SIT					
Left Eye	92	13.77	12.20	13.12-14.42	0.790
Right Eye	92	13.75	12.20	13.07-14.43	

9.1 CCT

ere were 132 LE and 129 RE included in the study. The LE mean CCT value was 0.51micrometres and the RE mean CCT was 520.12micrometres, giving a paired T-test = 8. This is statistically insignificant. ($p \leq 0.05$).

2 Goldmann Applanation Tonometry

paring 61 LE with 60 RE in the paired T-test gives a value of 0.716, which is tically not significant.

6.9.3 Schioetz Indentation Tonometry

Statistical computation between RE and LE shows a t-test value of 0.790 ($p \leq 0.05$). Therefore this is not statistically significant.

7. DISCUSSION

There were slightly more males than females with 54% to 46% respectively (Figure 1). The majority of subjects were in the age-group of 15 to 20 years with a relatively high number of school-going students seeking ophthalmic serves at the selected facilities during the survey period. Three patients had unilateral corneal perforation and hence only the non-affected eyes were included in the study. Sabatia and Litein eye units are well recognized eye care centres and schools tend to seek services at these institutions.

The proportion of Cushites (11%) in the study is significantly lower compared to Nilotes and Bantus (35% and 54%) respectively. This reflects regional variances in population demographics with Isiolo District being sparsely populated by predominantly nomadic pastoralists. Litein and Sabatia, however, are located in relatively densely populated areas.

While there is increasing intermarriage between various ethnic groups in Kenya, the locations chosen are considered to be relatively typical as they are located at the heartland of the respective communities surveyed.

Ocuscan RxP Pachymeter calibrations (pre-testing) at the Department of Ophthalmology, University of Nairobi, located at Kenyatta National Hospital, gave a reproducibility value of 99.1 - 99.5 %, hence intra-observer and equipment variability did not affect the CCT readings.

The mean CCT in this study was 521.43 micrometers at a standard deviation of $\pm$31.124 (table 2). This confirms previous studies that reported thinner CCT with lower IOP recordings in Africans and African-Americans. [3,39] The Ocular Hypertensive Treatment Study (N=1032) reported thinner corneas with mean CCT of 551.7 $\pm$ 40.0 micrometers for African Americans as compared to Caucasians with 573$\pm$39.0 micrometers.[2] This concurs with results from studies by Sunil Shah et al[38] and by Lifschitz et al. [39] The latter studied CCT in North Africans and a Jewish population from Israel and found North Africans to have a lower mean CCT of 518.9 $\pm$ 31.5 micrometers which is similar to our own study findings of a mean CCT of 521.43 $\pm$ 31.124 micrometers.

This is despite the fact that North Africans may reflect the influence of genetic and environmental factors different to those in the surveyed Kenyan communities.

There were more Bantus than Nilotes and Cushites included in our study (table 4) and this reflects variances in population demographics and economic activities of population. As CCT has a genetic disposition [41] one could expect differences between the surveyed populations. However, statistical correlation between Bantus, Nilotes and Cushites showed no statistical differences. This could be due to a common heritage or intermarriages resulting in genetic pleormophism in the examined populations.

It is noteworthy that the observed variances in the mean CCT values may also have been influenced by other factors as refractive errors and undetected corneal factors / topography known to affect CCT [40] but not considered in this study.

Correlation between CCT and GAT has been correlated in previous studies. [16, 18, 33, 42] This study, using Pearson Correlation (R) Significance (2 tailed), established R=0.292. Marcos et al [42] calculated R=0.184 and showed no positive correlation with SIT. We recommend where possible use of GAT. [42]

The presumed influence of genetic factors [41] and age [43] on CCT was reproduced in our study only as far, as the CCT in our African population was significantly thinner than those reported from studies with Caucasians.

Right eyes (N=129) and left eyes (N=132) had mean CCT values of 520.12 micrometers and 520.51 micrometers respectively. This was not statistically significant (T-Test = 0.88 at $P \leq 0.05$). GAT in ocular normotensives also showed no statistical variation in the IOP readings (T-Test = 0.716 at confidence interval $P \leq 0.05$). Spearman correlation between CCT and age by this study gave rho = 0.498, showing no relationship in the study sample. Kotecha A et al in a study on relative effects of corneal thickness and age on GAT showed that IOP correlates for young patients. However, advancing age confers corneal rigidity, hence age accounts for much of inter-subject variation.

This suggests that older patients generally have higher IOP readings with GAT. In our study the majority of patients where rather young between 15-20 years and this could have contributed the mean IOP of 15.04 mmHg at a mean CCT of 521.43micrometers[44].

There were great variations in numbers between the three ethnic groups, as Bantus contributed (54%), Nilotes (35%) and Cushites only (11%) to the study population. Using the Levene's Test for Equality of Variances P was 0.013 at a mean difference of 15.54. This is statistically insignificant at a confidence interval of 95% suggesting that the variation in numbers had no effect on CCT and tonometry readings in this study.

The following aspects may have influenced results as a potential source of error:

a) Intermarriage: Centres selected for the study may be in areas with high rates of intermarriage diffusing differences in CCT and IOP readings between the examined populations.
b) Equipment: Applanation and Schioetz tonometers used had not been calibrated for some time and this may have contributed to wrong IOP readings.
c) Diurnal variation in IOP: Most patients were attended between late morning and early afternoon. This may have affected some IOP readings as the circadian rhythm of IOP suggests higher readings in patients examined during morning hours.

8. CONCLUSIONS

1) This study suggests that African Kenyans of the selected communities have a significantly lower mean CCT of 521.43 micrometers compared to Caucasians (573.00micrometres) and African- Americans with 557.70 micrometers.

2) This finding may be of significance when addressing the important problem of Glaucoma blindness in Kenya and the region. It is now universally accepted that CCT affects IOP readings and thus the management of glaucoma and ocular hypertension.

3) The relatively thinner CCT in Kenyan Africans established for the first time with this study may lead to systematically underestimating actual IOP and therefore delaying or denying timely and adequate glaucoma treatment.

4) However, while there seems to be evidence from the literature that GAT is affected by CCT there is no evidence from our study that it also affects SIT, which is still widely used in peripheral eye units. However, SIT is generally considered relatively unreliable in the management of glaucoma.

5) This study can not be representative of the huge ethnic diversity in Kenya.

9. RECOMMENDATIONS

1) It is suggested that a broad based cross-sectional study be undertaken to test further representation and validity of the suggested trends. The Ocuscan Pachymeter has proven to be a reliable instrument for such studies

2) For individual patients in our setting with clinical changes suggestive of glaucoma but with regularly normal IOP readings it is recommended to measure CCT.

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11.2 APPENDIX II (CONSENT FORM)

I ..... of Box ..... And /or District ..... Hereby give consent to be included in this study.

I further state that the procedure has been explained to me and I fully understand and the procedure will be carried out under local anaesthesia.

Date.....

Signed .....

I confirm that I have explained the nature and effect of this procedure which entails measurement of intraocular pressures and central corneal thickness by pachymetry.

Date .....

Signed .....

11.3 APPENDIX III (PACHYMETRY TESTING AND CALIBRATION)

			15/06/05	16/06/05
1	Client No.1	OD	0.484	0.483
		OS	0.481	0.482
2	Client No.2	OD	0.51	0.518
		OS	0.50	0.506
3	Client No.3	OD	0.561	0.560
		OS	0.563	0.562
4	Client No.4	OD	0.523	0.523
		OS	0.525	0.524
5	Client No.5	OD	0.525	0.522
		OS	0.520	0.521
6	Client No.6	OD	0.537	0.535
		OS	0.542	0.540
7	Client No.7	OD	0.484	0.484
		OS	0.499	0.497

USING CORRELATION

1) OD: CORRELATION

X	Y	XY	X^2	Y^2
0.484	0.483	0.233772	0.234254	0.233289
0.51	0.518	0.26418	0.2601	0.268324
0.561	0.560	0.31416	0.314721	0.3136
0.523	0.523	0.273529	0.273529	0.273529
0.525	0.522	0.27405	0.275625	0.272484
0.537	0.535	0.287295	0.288369	0.286225
0.484	0.484	0.234256	0.234256	0.234256
$\Sigma x = 3.624$	$\Sigma y = 3.625$	$\Sigma xy = 1.881242$	$\Sigma x^2 = 1.880856$	$\Sigma y^2 = 1.881707$

Correlation is denoted by r:

If r is close to 1, accept 1 implies 100% accurate:

Therefore:

$$r = \frac{n\Sigma xy - \Sigma x \Sigma y}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

Where n is the number of samples,

Hence n = 7

$$\text{r} = \frac{(7 \times 1.881242) - (3.624)(3.625)}{\sqrt{[(7 \times 1.880856) - (3.624)^2][(7 \times 1.881707) - (3.625)^2]}}$$

$$\text{r} = \frac{13.168694 - 13.137}{\sqrt{[(13.165992) - (13.133376)][(13.171949) - (13.140625)}}$$

$$= \frac{0.031694}{\sqrt{[0.032616][0.031324]}} = \frac{0.031694}{\sqrt{0.001021663}}$$

$$= 0.991569376$$

is 1 or close 1, then accept.

1569376 is same as saying 99.1% accurate.

OS CORRELATION

X	Y	XY	X^2	Y^2
0.481	0.482	0.231842	0.231361	0.232324
0.50	0.506	0.253	0.25	0.256036
0.563	0.562	0.316406	0.316969	0.315844
0.525	0.524	0.2751	0.275625	0.274576
0.520	0.521	0.27092	0.2704	0.271441
0.542	0.540	0.29268	0.293764	0.2916
0.499	0.497	0.248003	0.249001	0.247009
$x = 3.63$	$\Sigma y = 3.632$	$\Sigma xy = 1.887951$	$\Sigma x^2 = 1.88712$	$\Sigma^2 = 1.88883$

$n = 7$

$$r = \frac{n\Sigma xy - \Sigma x \Sigma y}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

$$= \frac{(7x\ 1.887951) - (3.63 \times 3.632)}{\sqrt{[(7x1.88712) - (3.63)^2][(7 \times 1.88883) - (3.632)^2]}}$$

$$\frac{13.215657 - 13.18416}{\sqrt{[(13.20984-13.1769][13.22181-13.19424]}}$$

$$r = \frac{0.031497}{\sqrt{[0.03294]\,[0.030386]}}$$

$$r = \frac{0.031497}{\sqrt{0.001000914}}$$

$$r = \frac{0.031497}{0.031637238}$$

$$r = 0.995567312$$

lies = 99.5% accurate

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