Comparison of Contact and Non-contact Pachymeters in the Measurement of Central Corneal Thickness (CCT)

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Abstract

The Central Corneal Thickness (CCT) examination assists in the diagnosis of ocular diseases such as glaucoma, keratoconus and Fuch's dystrophy (FD). Several instruments used for the measurement of CCT include the ultrasound pachymeter, optical coherence tomography(OCT) machine, specular microscopy, A- Scan etc. The aim of this study was to evaluate the relationship and determine the repeatability of CCT measurements in an OCT machine and an ultrasound pachymeter. This was an observational study carried out in Sight Care Specialist Eye clinic, Benin City, Nigeria. CCT measurements were taken three times from each participant using both instruments and the average was noted. The data were analysed using Pearson Correlation and Analysis of Variance (ANOVA). Eighty participants (49 males and 31 females) with mean age of 43.1 ± 17.2years participated in the study. The mean CCT value for the ultrasound pachymetry for the right eye was 545.46±44.56mm and for the left eye was 546.45±49.35mm. The mean CCT value for the OCT machine in the right eye was 525.32±42.17mm and for the left eye was 524.95±46.43mm. There was also a strong positive significant relationship between OCT and Pachymeter ($r = 0.92$, $p = 0.001$) in both eyes. The OCT machine slightly underestimates the CCT values when compared to ultrasound pachymetry, however both CCT values were highly correlated. Therefore, the OCT machine can serve as an alternative for the measurement of CCT values due to the greater disadvantages associated with the use of ultrasound pachymetry.

Key words: central corneal thickness, ultrasound pachymeter, optical coherence tomography (OCT)

Introduction

Central Corneal Thickness (CCT) examination is the measurement of the central part of the cornea. The cornea is thickest at its periphery around the limbus and thinnest at the central portion, hence it is

important that when measuring the central corneal thickness, one ensures that it is the center as measuring anywhere else would give false values. The average range of CCT in the general adult population is 535 microns – 565 microns (Thiagarajan *et al.* 2021) and it has been said that there is diurnal variations in CCT as it is thicker in the morning than at night (Harper *et al.* 1996). CCT also varies with age - the older a person is, the thicker the cornea and ethnicity - with Africans having the thinnest corneas followed by mixed ethnicity and Caucasians. (Consantini *et al.* 2009; Baboolal, and Smit, 2018). Ultrasound pachymetry is the gold standard method for measuring central corneal thickness because of its reliability and accuracy (Comcali *et al*. 2016), and also because it is light weight and portable. The Optical Coherence Tomography test is a relatively new technique used to measure the CCT and it is a non-contact method. One advantage it offers over the ultrasound pachymeter is that it can locate the central corneal with great precision without any contact. It works based on optical interferometry, which uses interference patterns of laser light that is reflected to measure the layers of the cornea (Aref *et al.,* 2010). In a study carried out by Babbar *et al.,* (2017), concluded that ultrasound pachymeter may be the best and more accurate technique for measuring CCT because it showed the least variance among the other techniques (optical coherence tomography and specular microscopy). In addition, Comcali *et al., (*2016), observed lower values in CCT measurements in optical coherence tomography compared with ultrasound pachymetry. They stated that the difference may not be significant for glaucoma specialists but it is for refractive surgeons. It should be noted that underestimation of CCT may lead to the exclusion of patients who are rather suitable and qualified for refractive surgery.

Overestimation of CCT in patients who appear eligible for refractive surgery could lead to catastrophic complications such as corneal ectasia which occurs as a result of removing more tissue from the cornea than is healthy. Glaucoma, keratoconus and high refractive errors etc are eye diseases that can very much affect vision and a person's quality of life. Measuring the central corneal thickness accurately is one of the ways to diagnose these diseases, hence it is important that clinicians know the devices they can use interchangeably for this test so as not to get conflicting and confusing results. Therefore, this study seeks to evaluate and compare the repeatability of CCT measurements between the OCT machine and the ultrasound pachymetry and also to determine if they can be used interchangeably.

Materials and Methods

Research Design

This study was an observational study carried out at Sight Care specialist Eye clinic, Benin City, Nigeria. Eighty participants were selected using convenient sampling technique. This study was carried out within a duration of 3 months (April 2022 – June 2022). Participants that met the inclusion criteria included having no previous refractive surgery, no active ocular disease/abnormalities, no recent history of contact lens wear and no systemic disease with eye symptoms. In addition, participants that gave their informed consent were also included in the study.

Procedure for Data Collection

Sterilization Procedure

Before the examination ensued, the following were sterilized

1. The probe of the ultrasound pachymeter
2. The forehead rest of the OCT machine
3. The chin rest of the OCT machine

After the sterilisation procedure, the following tests were carried out before the pachymetry test was done. These tests were done to ensure the participants met the inclusion criteria and for legal purposes.

a. Case history
b. Visual Acuity test
c. External examination
d. Intra ocular pressure test
e. Internal examination

The OCT pachymetry was done before the contact technique to avoid any irregularities the probe or anesthesia might cause. The entire procedure was explained to the participant first as they were seated. The OCT machine was put on and set to measure the central corneal thickness. The cornea adaptor lens was fixed against the eye piece of the machine. The participant was asked to put their chin on the chin rest and forehead against the forehead rest. They were told to look into the adaptor lens . The measurements were taken three times and the average was noted down.

Next the Ultrasound pachymetry was carried out and the entire procedure was explained to the participant first, then one drop of the anesthesia was instilled in each of the eye of the participant and the ultrasound pachymeter was put on after which the participant was asked to fixate on the biggest letter on the VA chart. The probe was placed perpendicularly against the participant's cornea, with great care taken to ensure it was in the center. Three readings were taken with the average noted.The procedure was done between 9:00am and 12:00pm to avoid

the diurnal variation on corneal thickness (Harper *et.al.,* 1996).

Ethical Consideration

Ethical approval was obtained from the Ethical Committee of the Faculty of Optometry, University of Benin, Nigeria. This study was done in accordance with the tenets of the declaration of Helsinki. Informed consent was obtained from the study participants after thorough explanation of the procedure to them.

Data Analysis

The data collected were analyzed with SPSS version 23. The results of the analysis were presented in tables and charts. Statistics such as mean and standard deviation were used to describe the numeric variables while frequencies and percentages were used to describe the categorical variable. The relationship between readings of the OCT and Pachymeter readings was determined using Pearson correlation while ANOVA was used to test for the repeatability of measurements. A p-value of less than 0.05 was considered statistical significance.

Results

Descriptive Statistics

The age of the 80 study participants ranged from 16 – 77 years with the average being 43.1 ± 17.2 years. Among the participants, there were 49 males (61.2%) and 31 females (38 8%)

Table 1: The Demographic data of the participants

Demographic data	Frequency	Percent
Age		
15-35	32	40.0
36-56	27	33.8
57-77	21	26.3
Gender		
Male	49	61.2
Female	31	38.8

The table below summarises the Central Corneal Thickness (CCT) readings of ultrasound pachymetry and Optical Coherence Tomography (OCT). The ultrasound pachymetry CCT of the right eye (OD) ranged from 448.00 – 678.00mm with an average of 545.46 ± 44.56mm, while the OCT CCT reading of the right eye ranged from 440.00 – 657.00mm with an average of 525.32 ± 42.17mm.

Table 2: Descriptive statistics of the CCT readings of ultrasound Pachymetry and OCT

	Mean	Min	Max
Ultrasound Pachymetry(OD)	545.46 ± 44.56	448	678
Ultrasound Pachymetry(OS)	546.45 ± 49.35	460	687
OCT(OD)	525.32 ± 42.17	440	657
OCT(OS)	524.95 ± 46.43	441	676

OD = right eye; OS = left eye; Note all units are in millimetres (mm);

The table 2 above summarises the Central Corneal Thickness (CCT) readings of ultrasound pachymetry and Optical Coherence Tomography (OCT). The ultrasound pachymetry CCT of the right eye (OD) ranged from 448.00 – 678.00mm with an average of 545.46 ± 44.56mm while the OCT CCT reading of the right eye ranged from 440.00 – 657.00mm with an average of 525.32 ± 42.17mm.

The relationship between the CCT of OCT and Ultrasound Pachymetry

The table 3 below shows the correlation between CCT readings of OCT and ultrasound pachymetry. In both the left eye and right eye, there was a strong positive significant relationship between OCT and Pachymeter (r = 0.92, p = 0.001). This implied that an increasing ultrasound pachymetry CCT reading was associated with an increasing OCT reading. The trends are shown in the figure 1 and 2 below.

Table 3 Correlation between CCT of OCT and CCT of ultrasound pachymeter

	CCT_PACHY_OD	**CCT_PACHY_OS**
CCT_OCT_OD	**0.92******	
CCT_OCT_OS		**0.92******

****P = 0.001

This table shows the correlation coefficient to be 0.92 which shows that both instruments are highly correlated and that means that as the values of the ultrasound pachymetry increased, the OCT values increased too.

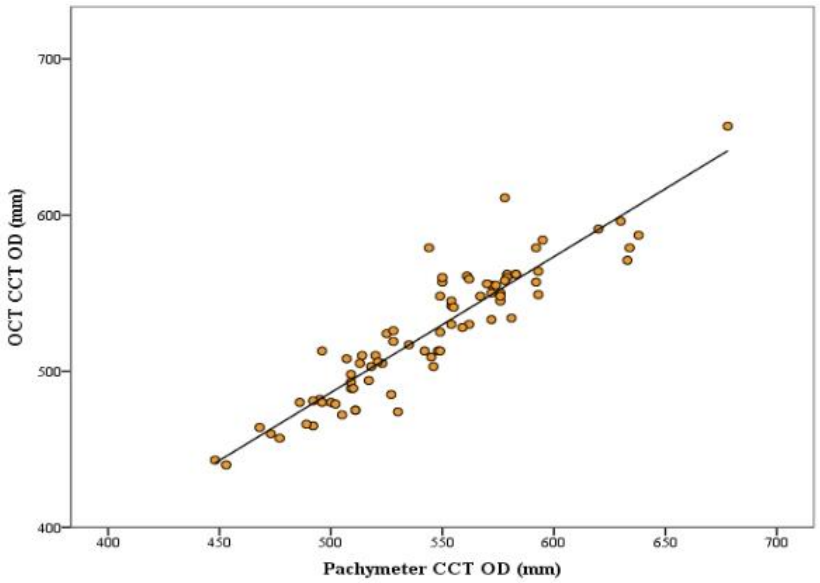

Figure 1: The relationship between ultrasound pachymetry and OCT in the right eye. This figure shows that in the right eye, as the CCT values increased with ultrasound pachymetry, the OCT values also increased.

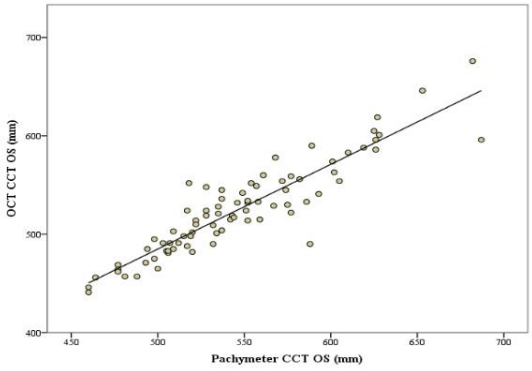

Figure 2: The relationship between ultrasound pachymetry and OCT in the left eye.

This figure shows that in the left eye, as the CCT values increased with ultrasound pachymetry, the OCT values also increased.

The repeatability of OCT and Ultrasound Pachymetry CCT measurements.

The table 4 below showed the averages of the first to third readings made by the instruments in both eyes. An analysis of variance (ANOVA) conducted showed that there is no significant difference among the readings in all cases ($p > 0.9$).

Table 4 : Repeatability of CCT measurements

Characteristic	R 1	R 2	R 3	p-value[2]
Ultrasound Pachymetry(OD)	544.71 + 44.60	544.71 + 44.55	544.74 + 44.58	1.000
Ultrasound Pachymetry (OS)	546.49 + 49.36	546.30 + 49.28	546.19 + 49.39	0.999
OCT (OD)	525.56 + 41.90	525.55 + 42.18	524.20 + 43.51	0.973
OCT (OS)	524.68 + 46.72	524.75 + 46.37	524.98 +46.38	0.981

Discussion

Measurement of the Central Corneal Thickness plays a very important role in the diagnosis, treatment and management of eye diseases. The most commonly used instrument for the measurement of CCT is the ultrasound pachymetry which has some disadvantages such as the requirement for topical anesthesia and the risk of cross-contamination because the probe is placed against the cornea. In the OCT method of

measurement, it is non-contact therefore, there is no high cross contamination risk and no need for anaesthesia.

In this study, the CCT value was consistently lower using the OCT machine than the ultrasound pachymeter with the mean CCT value of the ultrasound pachymeter for the right and left eye being 545.46±44.56 and 546.45±49.35 respectively, and the mean CCT value for the OCT machine for the right and left eye being 525.33±42.17 and 524.95±46.43 respectively. This was also seen in a study done by Leung *et al* (2006) where the CCT values measured with OCT were higher than those measured with the ultrasound pachymeter with a measured mean CCT of 528.55±35.11 µm with OCT and 530.47±33.39 µm with the ultrasound pachymeter. In another study done by Acar *et al* (2016), the mean CCT value was 536±37 µm with OCT and 559±36 µm with the ultrasound pachymeter, which showed that the mean CCT was about 22 µm lower with the OCT machine. Vollmer *et al* (2012) found the OCT machine measurements to be about 12 µm lower than the ultrasound pachymeter measurements. This was also observed in a study conducted by Northey *et al* (2012) where the mean CCT with OCT was observed to be 16 µm lower than the mean measurement performed by ultrasound pachymetry. Garcia-Medina *et al* (2013) also found out that the mean CCT measured with the OCT machine was 17 µm lower than the values measured with ultrasound pachymetry. In this study and the above-mentioned studies, CCT measured with the OCT machine was reported to be lower than ultrasound pachymetry measurements. It has been said that the reason for the difference between the readings obtained from the ultrasound pachymetry and OCT machine could be asides from interobserver variability, because of their mode of operation. In

ultrasound pachymetry, it is not known if the exact speed of sound in the tissues of the cornea can affect the CCT measurement, or if the fact that the true refractive index of infrared radiation in the cornea is not known in the OCT machine can affect the CCT measurement (Ramesh *et al.* 2017). Another reason for higher CCT readings with the ultrasound pachymetry is the use of anaesthetic drops which could cause corneal oedema (Comcali *et al.* 2016).

From this study, it was observed that the ultrasound measurements were not varied on repeated measurements and this was the same with the OCT machine measurements. The OCT machine showed slightly more variability in the measurements than ultrasound measurement (with the ultrasound pachymetry having a p-value of 1.000 in the right eye and the OCT having a p-value of 0.973 in the right eye) which means that the ultrasound pachymetry values remained constant despite numerous measurements. Vollmer *et al.* (2012) showed repeatability of 2.04 µm with ultrasound pachymetry and 1.92 µm with the OCT machine and Thiagarajan *et al* (2021)also discovered that the OCT showed more repeatability than the ultrasound pachymetry which is different from the result obtained in this study. This could be as a result of a difference in the skill/expertise of usage of these instruments.

Conclusion

The results of this study showed that the OCT machine gives or tends to slightly underestimate the CCT values when compared to ultrasound pachymetry but the difference was not statistically significant. It was also discovered that these instruments can be used interchangeably as the results show that they are highly correlated. In addition,

there was a difference in repeatability as the ultrasound pachymetry showed less variability in results so it is more reliable in that regard. The OCT machine can be used to check the CCT of patients as they are generally more comfortable with it than the ultrasound pachymetry which has more disadvantages than the OCT machine.

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