Original Article

Comparing Central Corneal Thickness Using Ultrasound and Anterior Segment Optical Coherence Tomography Pachymetry in Adults Attending A Private Eye Clinic in Abuja

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Abstract

Background: Central Corneal Thickness (CCT) measurement is useful in the management of glaucoma, ocular hypertension, corneal lesions and kerato-refractive surgeries. The study aims to compare the CCT measurements between Ultrasound Sonography (USS) and Optical Coherence Tomography (OCT), to analyze correlation and agreement between these instruments as well as repeatability of each instrument.
Methodology: A cross sectional comparative study carried in 100 eyes of 50 patients attending Rachel Eye Center in Abuja from January to March 2021. The CCT were taken using the USS and OCT. CCT was measured using the Pachscan ultrasound and the Optovue machine utilised for the OCT technique. Data was analysed using SPSS version 20 using Paired Sample t Test, Pearson's correlation, Interclass Correlation and Bland Altman Methods.
Results: Patients were aged between 18 and 79 (mean age of 39.1), 72 males and 28 females. The mean CCT was 537.36 ±33.26 and 510.94 ±33.13 for USS and OCT respectively with a mean difference of (26.42±9.53 $p<0.001$). There was a very strong correlation of the 2 sets of measurement $r = 0.997$ $p<0.001$. There was a high average mean intraclass correlation coefficient of 0.843 between the two instruments and this was excellent (0.961) within the 95 percentile upper limit but poor in the (0.096) lower limit. There was a high correlation and no statistical significant difference in the comparing repeated mean USS and OCT measurements. There was an excellent average mean Intraclass Correlation Coefficient of 0.999/0.997 for the repeated OCT and USS values and this was found to be excellent(0.999/0.998) within the 95 percentile upper limit and (0.997/0.994)lower limit respectively.
Conclusion: We find that measurements of CCT using the Pachscan ultrasound and the Optovue OCT correlate well, but the mean Pachscan measures were significantly higher than Optovue measures.
Keywords : Central Corneal Thickness; Ultrasound Pachymetry; Optical Coherent Tomography.

Introduction

Measurement of Central Corneal Thickness (CCT) measurement is now standard in ophthalmic practices around the world because of its immense importance. CCT is used both for glaucoma and kerato refractive surgery patients' management. The CCT is used to recalculate the corrected intraocular pressures (IOP), as individuals with thin corneas have an underestimated IOP and those with thick corneas have an overestimated IOP. A10% difference in the central thickness of the cornea could lead to a difference in intraocular pressure of up to 3.4 mmHg[1]. Hence the corrected IOP is the IOP used in monitoring glaucoma and ocular hypertension patients. The CCT is also

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Quick Response Code:
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How to cite this article: Okudo AC, Babalola OE. Comparing Central Corneal Thickness Using Ultrasound and Anterior Segment OCT Pachymetry In Adults Attending A Private Eye Clinic In Abuja. Niger Med J 2022;63;(1): 71-76

required to measure the amount of corneal tissue to ablate in kerato-refractive surgeries.

The gold standard instrument for measuring CCT has been the Ultrasound Pachymetry (USS). The ultrasound CCT assessment has its limitations as it is a contact test which often occasions patient anxiety. The numbness of the anesthetic drops also causes discomfort to the patients. The possibility of infection and abrasion to the cornea can also arise. Another issue is the exact position of the central cornea to be measured poses a challenge for multiple users[2,3]. Over the years various equipment have been manufactured to deal with these issues. One of which is the anterior segment OCT, which is a non-contact test and maps out the exact central cornea position to be measured. Other machines used to measure CCT include ultrasound biomicroscopy, confocal microscopy, slit-lamp pachymetry, non-contactspecular microscopy and scanning-slit corneal topography(Orbscan).

There have been various reports on comparing these two measures. Some reports say that the OCT gives statistically reduced readings as compared to USS[3-10]. Others say despite the fact that OCT gives reduced results, these findings showed no statistically significant difference[11-12]. The reverse was reported where the OCT gave higher results as compared to USS[13].

To our knowledge there is no studies that compare USS and Anterior Segment OCT CCT measurements in Nigerian eyes.

We have used the ultrasound pachymetry for years in our practice and want to study if the OCT pachymetry can conveniently replace the USS form of measurement. The study aims to compare USS and Anterior Segment OCT in measuring Central Corneal Thickness, CCT and to assess repeatability of the tests.

Materials and Methods

This is a cross-sectional comparative study carried out at Rachel Eye Center, Garki, Abuja from January to March 2021. One hundred eyes of 50 patients were included in the study, aged between 18 and 79. Participants with corneal pathologies, contact lens wear, secondary glaucoma, inflammation, past ocular surgeries, significant corneal astigmatism (astigmatism >1.5DC) and gross ocular pathologies were excluded. The study was in keeping with Helsinki's ethical guidelines. A written informed consent was obtained from all the participants. All participants had a detailed history and ophthalmic examination i.e., Snellen visual acuity, slit lamp examination, fundus examination and refraction. Consecutive patients who met the inclusion criteria and were willing to participate were included in the study. USS CCT was first measured using, PAC SCAN 300 AP Digital Biometric Meter Sonomed Incorporation, Escalon Medical Corp, U.S.A and then the OCT CCT was carried out using the iVue 100-2OPTOVUE Spectral Domain Optical Coherent Tomography, Drive, Premont, CA 94538 California, U.S.A. in that order at 10 minutes interval to the both eyes. The average of two successive readings was taken for all instruments. Anesthetic drops Gutt Proparacaine Hydrochloride 5mg/10mls with 0.0002ml of 50% Benzalkonium Chloride solution (Primax), one drop was instilled topically into the inferior fornix prior to measuring with USS and OCT. Measurements were taken between 9 and 11am, in a sitting position and by one examiner and using same instrument. Data was analyzed using SPSS statistical software (IBM *SPSS Statistics 20*; Chicago, *IL*, USA). using Paired Sample Student T-Test, Pearson's correlation coefficient, Bland Altman analysis, linear regression and Interclass Correlation.

Results

The participants included 50 subjects (100 eyes). There were 72 males and 28 females with a male: female ratio of (2.57:1). The mean age of the participants was 39.1 and median age of 32**.**

Table 1: Descriptive Statistics between OCT And USS

	USS	OCT
MEAN (SD)	537.36 ±33.26	510.94± 33.13
MEAN DIFFERENCE BETWEEN USS AND OCT (PAIRED SAMPLE T TEST)		26.42± 9.53 , P< 0.001
MEDIAN	534.00	510.00
MODE	517.00	525.00

The mean and standard deviation of the USS and OCT Pachymetry was 537.36 ±33.26 and 510.94 ±33.13; median was 534 and 510, mode 517 and 525 respectively. Comparing the two instruments using Paired sample test, there was a statistically higher

mean of 26.42±9.53µm, p<0.001 using the USS(Table 1).

Table 2: Pearson Correlation

	Pearson Correlation	P value
OCT and USS	0.959	<0.001
USS1 and USS2	0.994	<0.001
OCT1 and OCT2	0.997	<0.001

The correlation between the two instruments was found to be very high and was statistically significant r =0.959 p<0.001(Table 2). The correlation of the 2 sets of repeat USS CCT measurement was high r = 0.994 p<0.001 (Table 2). The correlation of the 2 sets of repeat OCT CCT measurement was higher than the USS r = 0.997 p<0.001 (Table 2).

Table 3: The Means of the two Repeated Test

	MEAN	MEAN DIFFERENCE OF BOTH READINGS
USS 1	537.460 ± 33.424	0.200± 3.796 (p=0.711)
USS 2	537.260 ± 33.443	
OCT 1	510.980 ± 33.012	0.080± 2.554 (p=0.826)
OCT 2	510.900± 33.585	

The repeated USS mean values were (537.46±33.42/537.26±33.44) with a mean difference of 0.20±3.8 p0.711(Table 3).

The repeated OCT mean values were (510.98±33.01/510.90±33.59) with a mean difference of 0.08±2.55 p=0.826. (Table 3).

Table 4: Interclass Correlation Coefficient (ICC)

	Intraclass correlation	95% confidence Interval Lower bound	95% confidence Interval Upper bound	P value
ICC (USS/OCT)				
Single Measures	0.728	-0.046	0.926	<0.001
Average Measures	0.843	-0.096	0.961	<0.001
ICC (USS1/USS2)				
Single Measures	0.994	0.989	0.996	<0.001
Average Measures	0.997	0.994	0.998	<0.001
ICC(OCT1/OCT2)				
Single Measures	0.997	0995	0.998	<0.001
Average Measures	0.999	0.997	0.999	<0.001

If the average interclass correlation is greater than 0.7, it is then acceptable, if greater than 0.9, it is excellent.

There was a high average mean intraclass correlation coefficient of 0.843 between the two instruments and this was found to be excellent (0.961) within the 95-percentile upper limit but poor in the (-0.096) lower limit (Table 4).

There was an excellent average mean intrasession repeatability correlation coefficient of 0.997 for the USS and this was found to be excellent (0.998) within the 95-percentile upper limit and (0.994) lower limit (Table 4).

There average mean intrasession repeatability correlation coefficient of the OCT (0.999) was higher than the USS and this was found to be excellent (0.999) within the 95 percentile upper limit and (0.997) lower limit, again higher than the USS (Table 4).

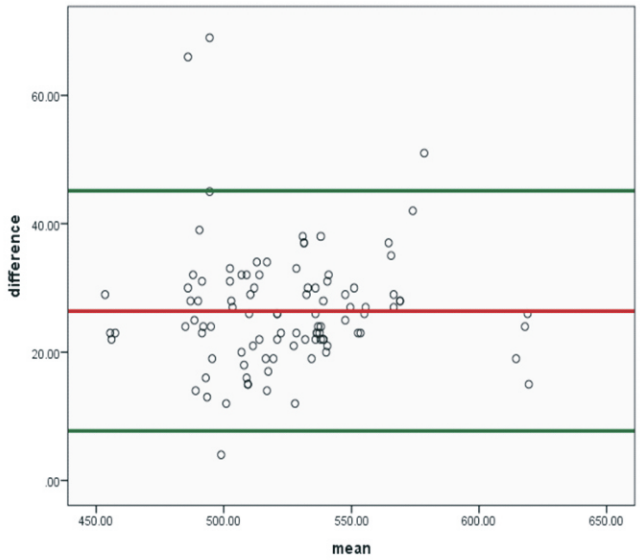

Figure 1: Bland Altmans plot with 95% limit of agreement

The Bland–Altman plot revealed mean differences of 26.42±9.537µm between OCT and USP. The 95 % Limit of Agreement LOA were calculated based on a 1.96 SD difference between OCT and USP. LOA was 7.726µm to 45.114µm. Four mean difference values were situated outside the LOA: 4,51,66 and 69µm (Figure1).

Discussion

The gold standard measure for pachymetry has for many decades been the ultrasound measurement. The ultrasound measure has its limitation which includes the inconvenience of it being a contact test which occasions patients' anxiety and risk of

infection and abrasion to the cornea. Another issue is the exact position of where the central cornea should be , the positioning of patient and the person doing the test as there are higher chances of interobserver error in mapping out the central cornea .The discomfort of having the eyes feel numb and the potential increase in corneal thickness[16,17,18] due to swelling of the cornea following the use of anesthetic drops is also of concern. Over the years various equipments have been manufactured to deal with these issues. One of which is the anterior segment OCT, which is a non-contact test. It maps out the area of the central cornea thickness and measures the central and paracentral and peripheral regions.

We have used the ultrasound pachymetry for years in our practice and wanted to study if the OCT pachymetry could conveniently replace the USS form of measurement. The study aimed to compare USS and Anterior Segment OCT in measuring central corneal thickness, and to assess the repeatability of each test.

The study showed that the mean CCT using the OCT (510.94 ± 33.13) was significantly lower than the USS (537.36 ± 33.26) with a mean difference of 26.42± 9.53 p<0.001. Hence caution has to be taken as these two methods cannot be used interchangeably. In clinical practice we have to take into consideration the lower values OCT measurements produce. These lower OCT values would cause further falsely elevated corrected pressure values. Hence a different algorithm may need to be used in correcting intraocular pressure as compared to the USS. Possible reasons for the OCT giving reduced CCT values as compared to USS include the possibility of not measuring the actual central cornea position as there is an increase chances of interobserver error since the actual position to be measured is the tip of the cornea but this region is not fixed or mapped out by the USS and depends on where the position the individual carrying out the test points to. This then increases the chances of interobserver error. Another difference might be peculiarities of both instruments.

OCT CCT values were significantly lower than USS CCT values and has been reported by the following studies. Peteras et al[9] reported USS vs OCT (547.27±44.24 vs 536.42±40.35 p<0.001), Ramesh et al[4] reported (RE 532.42±29.71 vs 516.28±29.76 p<0.001) and (LE 532.36 ±29.83 vs 515.82±29.88 p<0.001) with a mean difference of RE 16.14µm and LE 16.54um. Babbar et al[6] reported USS vs OCT (531.47±42.20 vs 517.62±43.29 p<0.001) with a mean difference of 13.84±1.09. Comeeali et al[11] also reported (544.27±33.6 vs 533.90±30 p<0.001). Acar et al[10] also reported OCT vs USS was 536±37υm vs 559±36µm with the a statistically significant mean difference of about 22υm[10]. Similar reports have also been found by other studies[5,7,8].

Some studies have also shown lower values but these values were not statistically different. For instance, Khaja et al[12] reported that USS mean was548.16±48.68um and OCT was 546.36±44.17um with a mean difference of 1.80 and no statistically significant difference p<0.88. Keskin et al[13] reported the mean CCT as 528.55±35.11µm with OCT and 530.47±33.39 □m with USS and the difference was not statistically significant. The reverse trend from the above has been reported by Marcelo et al where OCT values were higher than USS values but this was not statistically significant (USS vs OCT (532±32vs 536±28 um p=0.32)[15]. Similar findings have also been reported by Leung et al[14]. These differences could have arisen because of the peculiarities of the different brands of machines used. The brand used in Kayla et al study for OCT was OCT (3DOCT-20000; Topcon Corporation, 75–1 Hasunuma-Cho, Tokyo, Japan) and USS brand was USP (Tomey Pachymetry; Tomey Corp, Nagoya 451–0051, Japan) which differed from the other brand used above. Ayala et al[14] also explained possible difference
arising from differences in calibration and methods of measurements.

There was a very high positive correlation between the two instrument (r = 0.959p<0.001) and this was statistically significant. This means there is a high level of association or the measure of the extent to which the two measurements are related, so a measure of how one measurement increases as the other increases or decreases as the other decreases. Various other studies have also reported this high

level of correlation, r = 0.96p<0.001 by Khaja et al[12], r=0.93 ,P<0.0001 by Babbar et al[6], and r=0.895 p<0.001 by Ramesh et al[4]. Correlation as an assessment tool to compare two instruments has its short fall. Two instruments can have high degree of correlation (i.e., the measure to which one increases as the other increases or the measure to which one decreases as the other decreases) but still have a poor agreement[8]. Other test that shows a better test of agreement include the Bland Altman's test and interclass correlation. The Intra class correlation of the two instruments (0.843) was found to be good. The ICC was found to be excellent (0.961) in the 95th percentile i.e., upper limit but poor in the lower limit (-0.096). This means the level of correlation was excellent for higher CCT values and poor and negative relationship for lower CCT values. ICC was said to be 0.95 as reported by Khaja[12] but he did not look at the ICC at the lower and upper limits. To get a clearer understanding of these statistical analysis tools with regards agreement, the first test to carry out is the Paired Student T test, this gives the mean of the two instruments and states if there is a significant difference in the two measures, if a statistical difference exist then the two instruments cannot agree[15]. If the two instruments don't have a statistically significant difference, then a Bland Altman's test is carried out to understand the level of agreement within a 95% confidence interval to better understand the range and level of agreement and see the outliers i.e., the regions of weak agreements[16]. An interclass correlation also explains the level of agreement within the upper and lower 95% confidence interval[17]. From this study there was already a statistically significant difference using the Paired Student T test, although a Pearson correlation, Bland Altman and Interclass correlation was still carried out to better understand the correlation, agreement, strengths and limitation within the 95%confidence interval in this study.

To determine the repeatability of the two values gotten for each instrument, the mean difference, correlation and Interclass correlation (ICC) or intrasession repeatability was used. The mean of the two values of the USS were (537.46±33.42/537.26±33.44) with a mean difference of 0.20±3.8, p=0. 714.The mean difference was very small(0.2) and there was no statistical difference in the two reading of the USSCCT results, so this repeatability is very good. The correlation of the two results were also very high and statistically significant as correlation for USS was r = 0.994 p<0.001. Similar findings were seen in the OCT mean values of carrying out the test twice(510.98±33.01/510.90±33.59) with a mean difference of 0.08±2.55 p=0.714 and the correlation of the two results were also very high and statistically significant as correlation for OCT was r = 0.997 p<0.001.The ICC was also used to compare the mean values of the repeated USS and OCT values individually, in order to test the intra repeatability of each instruments .The intrasession repeatability of the USS was found to be 0.997 which is excellent. This cuts across for the lower bound and upper bound 95% confidence level measures (0.994-0.998), so regardless of how high or low the values are the repeatability is excellent. The same applies for the OCT measures as the intrasession repeatability was 0.999 and the lower bound and upper bound 95% confidence level measures were (0.997-0.999). It is worthy of note that using the three statistical analyses to study repeatability of these instruments the OCT had a better repeatability than the USS although both showed excellent repeatability results. Ayala et al[14] also reported on the ICC of OCT and USS CCT readings performed by three different people (the consultant ophthalmologist, resident and ophthalmic nurse). Both OCT and USS had excellent ICC when taken by three different people which was also similar to the ICC gotten in our study although ours the test was repeated by the same person. The ICC of the OCT was found to be higher than the USS in both studies. This means that repeatability of both the OCT and USS when taken by the same person or different people has been found to be excellent and the OCT was higher. Their USS instrument ICC was 0.97 (CI = 0.95–0.98), while OCT ICC was 0.99(CI = 0.98–0.996). It should be noted that the ICC result is classified as follows: 0.7–0.79 = good; 0.8–0.89 = very good; and, 0.9–0.99 = excellent consistency. Lin et al also reported the intra- and inter-class repeatability of OCT pachymetry to be good and better than USS[18].

In conclusion, we find that measurements of CCC using the Pachscan ultrasound and the Optovue OCT correlate well, but the mean Pachscan

measures were significantly higher than Optovue measures. This suggests that the two methods are not necessarily interchangeable and perhaps a different IOP correction algorithm may need to be developed for the OCT method.

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