ORIGINAL ARTICLE

Comparison of Central Corneal Thickness Using Ultrasound and Optical Pachymetry

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Abstract:

Objectives: To compare the mean difference in Central Corneal Thickness (CCT), between Standard Ultrasound Pachymetry and Optical Biometry scans, in healthy individuals.

Materials and Methods: This cross-sectional study was carried out from 01-02-2023 to 31-07-2023, using non-probability consecutive sampling, at the Department of Ophthalmology, PAF Hospital E-9 Islamabad. A sample size of 100 eyes was calculated, using the WHO calculator. First, the participant's CCT was measured using an Optical biometry AL Scan. Then the same participant's ultrasound pachymetry was performed and the results were compared.

Results: A total of 50 (100 eyes) participants were included in the study. With 33 (66%) male and 17 (34%) female participants. The mean age of the participants was 21.92±4.024 years, the mean Ultrasound CCT was 554.04±38.674 μm, and the mean Optical CCT was 539.45±35.666 μm. The mean difference in ultrasound and optical CCT was 15.09±10.309 μm. The paired samples t-test showed that the mean ultrasound CCT of 554.04±38.674 μm was greater than the mean optical CCT of 539.45±35.666 μm, and the difference was statistically significant ($p < 0.05$).

Conclusion: Even though the CCT measurements between ultrasound and optical pachymetry are comparable and repeatable, they cannot be used interchangeably in follow up visits in clinics. The study also proved a linear correlation between the two modalities, in which if one reading increases, the other increases as well, and vice versa. The CCT measurements by optical pachymeter were lower than by USP (Ultrasound Pachymeter). *Al-Shifa Journal of Ophthalmology 2024; 20(3): 111-118. © Al-Shifa Trust Eye Hospital, Rawalpindi, Pakistan.*

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Introduction:

A cornea that is in good health along with a layer of tear film above it, is important in offering a good superficial forward refracting plane, preventing the eye from various kinds of infections and guarding the inner sections of the eye. In an adult, the mean horizontal diameter of the cornea is 11.5-12mm[1] whereas vertically the corneal diameter is around 10.5-11mm (Figure 1). The refractive power of the anterior part of the cornea is around +43.00 to +43.50 diopters (D). The shape of the cornea is elliptical, relatively steep at the center, and horizontally smooth at the edges, forming optical system that is aspherical.With the increased awareness of refractive and cataract surgeries, its availability and expertise, the measurement of central corneal thickness (CCT) has become more widely used.[2,3] CCT assessment is also

important due to its effect on intraocular pressure (IOP) measurement, thus, it helps in, differentiating Normal Tension Glaucoma from Primary Open Angle Glaucoma,[4] and their management. CCT is also an important parameter in the diagnosis of corneal diseases such as Keratoconus and Fuch's Endothelial Dystrophy.[5]

For cataract surgeries, CCT is one of the variables in calculating the power of Intraocular Lens (IOL) and selecting patients for Laser in situ Keratomileusis (LASIK), where 300μm is the minimum residual stromal bed necessary to prevent post-op Keratectasia.[6]

There are multiple devices that are used for the measurement of CCT, based on optical and ultrasound modalities.[7] Ultrasound Pachymetry (USP) is the gold standard and the most commonly used technique for measuring CCT. However, it has a few disadvantages, it requires direct contact of the ultrasound probe with the anterior corneal surface, needs topical anesthesia, has an increased risk of transmission of infection, and for best results, corneal indentation must be done on the same point of the cornea which may lead to corneal epithelial damage. Furthermore, many times the user is unable to centralize the probe or the patient unable to fixate the gaze, leading to inaccurate measurements.[8] Therefore, now different devices are being used to measure CCT, with methods that provide quick, repeatable, and interchangeable measurements.[9] These include Pentacam Corneal Topographer, Anterior Segment optical coherence tomography (AS-OCT), and non-contact tonopachymeter.[10] In a study conducted by Biomedical Department, Course of Optics and Optometry, University of West Attica, Athens, The mean±SD (standard deviation) of central corneal thickness by ultrasound pachymetry (PachPen Handheld Pachymeter, Keeler Instruments Inc), ocular biometry (IOL Master 700 Swept Source Biometry, Zeiss) and Angiovue optical coherence tomography (Optovue Avanti RTVue XR Angiovue) were 547.26±44.24 μm, 551.36±48.87 μm, and 536.42±40.35 μm, respectively. There were statistically significant differences in the measurement results among the 3 methods.[5]

There are diseases in which doctors need to monitor the CCT of their patients in the long run. For this, we need to have access to devices that can be used interchangeably and have good repeatability. If this is achieved, then we can use optical devices with full confidence and prevent transmission of infection from one patient to another, as is the drawback for USP. Multiple studies conducted around the globe compare CCT using optical and ultrasound pachymetry, however, very few studies have been conducted in Islamabad specifically and are not conclusive. We aim to compare CCT measurements using Ultrasound Pachymeter and Optical Biometry AL Scan, in Islamabad. To the best of our knowledge, Optical Biometry AL Scan in particular, have not been compared in this part of the world, as yet. So, we assess the intra-operator repeatability of measurement with each device.

Materials and Methods:

This Cross-Sectional Study was carried out at the Department of Ophthalmology, PAF Hospital, Islamabad, from 01-02-2023 to 31-07-2023, after approval from the institute's ethical committee. Non-probability Consecutive sampling was used. Both genders and ages 18-50 years were included, whereas patients with ocular diseases like high myopia, glaucoma, contact lens use, or previous surgeries were excluded, along with the ones having systemic illnesses.

Written consent was taken from all participants. After a detailed history participants underwent visual acuity assessment, subjective and objective refraction, and finally a slit lamp and fundal examination were done.

CCT was then measured, first by non-contact optical pachymetry (NIDEK Optical Biometer AL Scan). Subjects were asked to sit with their chin up and their forehead touching the forehead bar, lateral lid canthus was aligned with the engraved lines on the device. They were asked to look at the fixation target. Multiple images were captured by the device and it measured the CCT. Subjects were told to move back, rest, blink, and then position their heads again, once the device was ready to take new scans. Three consecutive readings were taken and an average CCT was recorded.

Participants were then counselled regarding USP, we used Pocket II One Touch Ultrasound Pachymeter from Quantel Medical, and after 5 minutes topical anesthesia (proparacaine hydrochloride 0.5%) was instilled in both eyes. After 60 seconds the subjects were told to look at a far target, the ultrasound probe was positioned right at the center of the cornea, CCT was measured 3 times, and an average was taken. The probe was then sterilized to avoid transmission of infection. Optical and ultrasound CCT measurements were taken by different personnel to avoid bias. Optical results were not shared with the person taking ultrasound CCT. However, the same examiner took optical CCT measurements in all participants and the other person remained consistent in taking ultrasound CCT measurements from all participants. This was to prevent differences in readings due to examiner bias.

To avoid diurnal variation in the corneal thickness, all measurements were taken at least 3 hours after waking up (between 10 am to 2 pm).

The collected data were entered and then analyzed using SPSS version 24.0. All the quantitative variables, such as age, K-readings, and CCT (using ultrasound and optical pachymetry) were shown as mean and SD. Whereas, frequency and percentage were used to show qualitative variables like gender, type of refractive error (if any), and the anatomical side of the eye. Mean CCT was compared by Paired sample t-test. A p value ≤ 0.05 was taken as significant. Data was stratified for gender, age, anatomical side and refractive error. After stratification, Paired sample t-test was applied for ultrasound and optical CCT.

Results:

A total of 50 participants (100 eyes) were included in the study. With 33 (66%) male and 17 (34%) female participants. Both eyes of all participants were included in the study as they fit in the inclusion criteria, so we had 50 (50%) right eyes and 50 (50%) left eyes. The types of refractive error were Emmetropia in 54 eyes (54%), Myopia in 20 eyes (20%), Hyperopia in 1 eye (1%) and Astigmatism in 25 eyes (25%).

The mean K1 reading was 43.1841±1.43218 Diopters and the mean K2 reading of all the eyes was 44.1570±1.48424 Diopters.

The mean age of the participants was 21.92±4.024 years, the mean Ultrasound CCT was 554.04±38.674 μm, and the mean Optical CCT was 539.45±35.666 μm. The mean difference in ultrasound and optical CCT was 15.09±10.309 μm as shown in Table 1, Figures 1 and 2.

The mean ultrasound CCT of patients with emmetropic eyes was 557.78±37.877 μm, those with myopic eyes was 540.90±42.603 μm, in the 1 hyperopic eye it was 606.00 μm and lastly in the astigmatic eyes it was 554.40±35.732μm. The mean optical CCT in patients with emmetropic eyes was 542.74±35.695 μm, in those with myopic eyes was 528.60±35.652 μm, in the 1 hyperopic eye it was 589.00 μm and lastly in the astigmatic eyes it was 5539.04±34.675μm. The mean difference in CCT in patients with emmetropic eyes was 15.96±10.211 μm, in those with myopic eyes, was 12.30±11.188 μm, in the 1 hyperopic eye it was 17.00 μm and lastly in the astigmatic eyes it was 15.09±10.309μm.

The mean ultrasound CCT of patients in their right and left eyes was 553.94±39.449 μm and 554.14±38.284 μm respectively. The mean optical CCT in patients in right

and left eyes was 540.80±35.550 µm and 538.10±36.091 µm respectively. The mean difference in CCT in patients in right and left eyes was 13.50±10.041 µm and 16.68±10.428 µm respectively.

The mean ultrasound CCT in the eyes of males and females was 553.30±42.931 µm and 555.47±29.216 µm respectively. The mean optical CCT in the eyes of males and females was 537.41±9.39.160 µm and 543.41±27.771 µm respectively. The mean difference in CCT in the eyes of males and females was 15.89±9.552 µm and 13.53±11.634 µm respectively.

The data was stratified for age. Group 1 had participants from 18 to 24 years while group 2 had people from 25 to 31 years of age. The mean ultrasound CCT for Group 1, which had 74 eyes, was 553.32±42.133 µm and Group 2, having 26 eyes, was 556.08±27.086 µm. The mean optical CCT for Group 1 was 539.09±38.771 µm and for Group 2 was 540.46±25.433 µm. The mean difference in CCT in Groups 1 and 2 was 14.91±10.467 µm and 15.62±10.028 µm respectively.

Paired samples t-test showed that the mean ultrasound CCT (M= 554.04, SD= 38.674 µm) was greater than the mean optical CCT (M= 539.45, SD= 35.666 µm); $p < 0.05$ and the difference was statistically significant, as shown in Table 2.

The two modalities, ultrasound pachymeter and optical pachymeter (AL Scan) also show a statistically significant linear correlation (r= 0.958), as shown in Table 3 and Figure 3.

Table 1: Descriptive statistics

Descriptive statistics	Mean	Standard deviation
Age (years)	21.92	4.024
Ultrasound CCT (µm)	554.04	38.674
Optical CCT (µm)	539.45	35.666
Difference (µm)	15.09	10.309

Table 2: Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Ultrasound - Optical	14.590	11.127	1.113	12.382	16.798	13.112	99	.000

Table 3: Pearson Correlation

Correlations		
		Optical
Ultrasound	Pearson Correlation	.958**
	Sig. (2-tailed)	.000
	N	100
**. Correlation is significant at the 0.01 level (2-tailed).		

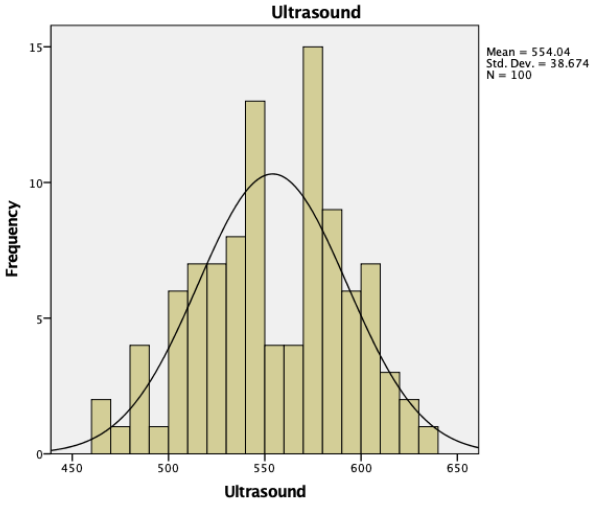

Figure 1: Histogram showing ultrasound CCT of participants

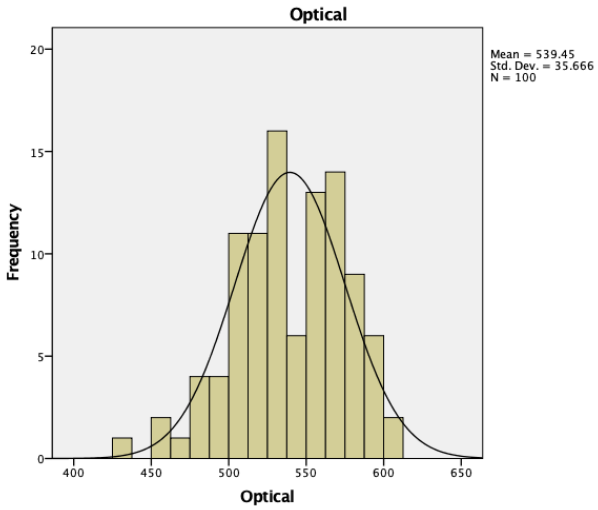

Figure 2: Histogram showing optical CCT of participants

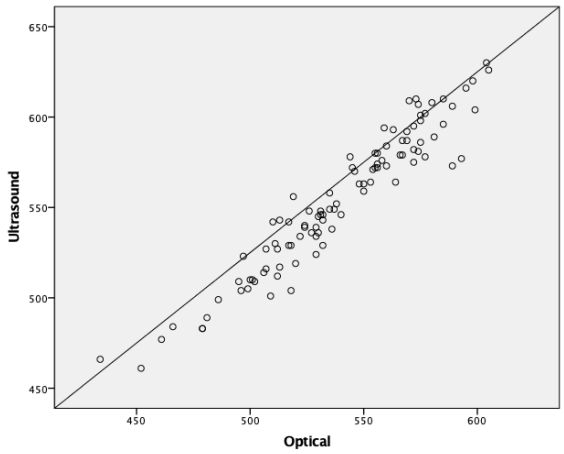

Figure 3: Scatter Plot showing Ultrasound vs Optical CCT

Discussion:

The gold standard investigation for central corneal thickness is ultrasound pachymetry.[11] However, it has been replaced largely by different devices containing optical pachymeter. Most of the clinical studies have analysed that ultrasound and optical pachymetry even though comparable, cannot be used interchangeably.[12]

Repeatability is the ability of a device to give similar results at separate occasions. Whereas interchangeability is when similar results are achieved by using two different devices, for example for CCT measurement at follow up visits. Thus, in our study, optical and ultrasound pachymetry are compared.

In the current study the mean ultrasound CCT (Pocket II One Touch Ultrasound Pachymeter), optical CCT (by NIDEK Optical Biometer AL Scan) and the mean difference in CCT were 554.04±38.674 μm, 539.45±35.666 μm and 15.09±10.309 μm respectively. This was in agreement with the study by Pateras et al, [5] which showed

that their mean ultrasound CCT (PachPen Handheld Pachymeter) was 547.26 ± 44.24 μm and with optical biometry (Zeiss IOL Master 700), 531.36 ± 48.87 μm, with the mean difference in CCT being 15.90 μm.

Our study showed that CCT with the two methods was repeatable and comparable as shown by Şimşek et al. [13] other optical devices also show a good correlation with USP.

Üçer et al compared three devices, all having the optical principle, and their result was statistically significant, with all three devices correlating closely.[7]

CCT assessment is also important due to its effect on intraocular pressure (IOP) measurement, thus, it helps in, differentiating Normal Tension Glaucoma from Primary Open Angle Glaucoma, and their management. For this reason, glaucoma patients were included in a study by Babbar et al.[14] There was a strong correlation among the three modalities that were tested. A study by Jiang et al[8] showed that interchangeability was low even between two optical devices like Zeiss IOL Master 700 and Tomey EM-3000 let alone between ultrasound and optical pachymetry, as is proven in our present study.

In contrast, Maloca et al studied USP with six other optical devices, the results showed inter-device variability as high as 120μm, but showed that OCT based devices showed better results than the other optical devices.[15]

Other studies also show repeatability in the ultrasound pachymetry,[16] but they advised using the same device on follow-up visits. However, the fact that ultrasound pachymeter is observer-dependent, other studies concluded that its reliability may be good, but it may show deviation between examiners. The fact that USP depends on the topical anesthetic also affects the CCT, some studies report up to 10μm.[10]

For cataract surgeries, CCT is one of the variables in calculating the power of Intraocular Lens (IOL) and selecting patients for Laser in situ Keratomileusis (LASIK), where 300μm is the minimum residual stromal bed necessary to prevent post op Keratectasia.[17]

Although USP is the gold standard for measuring CCT, it has a few disadvantages, it requires direct contact of the ultrasound probe with the anterior corneal surface, needs topical anesthesia, it has an increased risk of transmission of infection, for best results corneal indentation must be done on the same point of the cornea and it may lead to corneal epithelial damage. Furthermore, many times the user is unable to centralize the probe or the patient unable to fixate the gaze, leading to inaccurate measurements.[8] Therefore, now different devices are being used to measure CCT, with methods that provide quick, repeatable, and interchangeable measurements.[9] However, our current study proved that the CCT measured by optical pachymeter, although repeatable and comparable cannot be used interchangeably, since the Paired samples t-test showed that the mean ultrasound CCT (M= 554.04, SD= 38.674 μm) was greater than the mean optical CCT (M= 539.45, SD= 35.666 μm); $p < 0.05$ and the difference was statistically significant. The two modalities, ultrasound pachymeter and optical pachymeter (AL Scan) also show a statistically significant linear correlation (r= 0.958), which means that the CCT measurements from the two devices are directly proportional to each other. However, the study was conducted in a single setup, which limits it being generalized.

Conclusion:

Even though the CCT measurements between ultrasound and optical pachymetry are comparable and repeatable, they cannot be used interchangeably in follow up visits in clinics. The study also proved a linear correlation between the two modalities, in which if one reading increases, the other increases as well and vice versa. The CCT measurement by optical pachymeter were lower than by USP.

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