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Original Article

Central Corneal Thickness: Ultrasound Pachymetry Verus Anterior Segment Optical Coherence Tomography

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ABSTRACT

Purpose: To determine the mean difference in central corneal thickness between ultrasound pachymetry and anterior segment optical coherence tomography in patients visiting tertiary care hospital of Karachi.

Study Design: Cross sectional study.

Place and Duration of Study: Department of Ophthalmology, Liaquat National Hospital, Karachi from 27th December 2018 to 26th June 2019.

Methods: Total 216 eyes of 108 patients were divided into two groups. Central corneal thickness was measured using ultrasound pachymeters in group A and with anterior segment optical coherence tomography in group B. Data was collected and analyzed using SPSS version 21. Mean central corneal thickness was compared between the two methods. Stratification was done on gender, age and post-stratification independent sample t-test was applied for mean difference CCT and P-value ≤ 0.05 was taken as significant.

Results: Total 108 patients were equally divided into two groups. Mean age was 48.70 ± 7.82 years in group A and 50.66 ± 6.88 years in group B. In group A, there were 74.1% males and 25.9% females while in group B, there were 75.9% males and 24.1% females. There was statistically significant difference between the mean central corneal thickness of group A and group B for right and left eyes ($p < 0.001$). Mean difference was also compared for gender and age groups. We found statistically significant differences in central corneal thickness in between the two methods in both age groups (≤45 years and > 45 years).

Conclusion: Central corneal thickness was more with pachymeters as compared to the AS-OCT (p value < 0.05).

Key Words: Central Corneal Thickness, Anterior Segment Optical Coherence Tomography, Ultrasound Pachymetry.

How to Cite this Article: Ali W, Shakir M, Wasim S, Afza R. Comparison of Central Corneal Thickness: Ultrasound Pachymetry Verus Anterior Segment Optical Coherence Tomography. Pak J Ophthalmol. 2021, **37 (4):** 379-383.

Doi: 10.36351/pjo.v37i4.1260

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Received: April 29, 2021
Accepted: August 8, 2021

INTRODUCTION

One of the important and sensitive indicator of corneal health is central corneal thickness.[1] Measurement of corneal thickness is crucial in many clinical and research projects.[2] It is also integral for the diagnosis and management of treatable ocular conditions such as dystrophies of cornea, corneal edema, and endothelial diseases.[3,4] In the era of refractive surgery there is an increasing demand for a more accurate measurement

of corneal thickness.[5] If the measurements are not accurate, it can cause excessive tissue removal from the stromal bed that can lead to complication like iatrogenic corneal ectasia.[6] The gold-standard approach to measure CCT is ultrasound pachymetry (USP). Errors can occur in measurements if the centration of corneal measurement is not considered. Incidence of ultrasound waves on the cornea is not accurate; lack of control of gaze fixation, fluctuation of the sound speed across tissues, or by the use of any topical anesthetic agent can also lead to errors.[3] It can also occur with insufficient tear film displacement after probe compression.[4]

Recently, Anterior segment OCT (AS-OCT) has been introduced which is a noncontact method of central corneal thickness measurement. AS-OCT can objectively determine central corneal thickness with higher precision and convenience with no risk of corneal contamination and no need for topical anesthesia.[7,8] In addition, AS-OCT also provides assessment for corneal surgeries such as corneal cross-linking and intra-stromal ring placement and also detect and provide treatment plan for glaucoma by measuring central corneal thickness and anterior chamber angle width.[3]

Fourier domain OCT studies reported that the ultrasound CCT values were higher than the OCT values.[1] Measurement of CCT by AS-OCT was consistently thinner than measured by USP. Both measurement modalities had good intra-examiner and inter-examiner repeatability.[7] Ultrasound pachymetry, being a contact method, is uncomfortable for the patient and there is always a margin of technician error. Previous international studies also indicate that the research on this subject has been insufficient.

The purpose of our study is to determine the measurement of central corneal thickness by both the techniques, (Ultrasound pachymetry and Anterior segment OCT) and consequently find out whether there is a significant difference between the two or not that can affect our results so that these techniques can be interchangeable. This study will also find out baseline data of these two techniques in our setup.

METHODS

The study was conducted in Department of Ophthalmology, Liaquat National Hospital, Karachi within the duration of six months from 27th December 2018 to 26th June 2019after approval from hospital ethical review committee. The sample size was calculated using open Epi sample size calculator considering 516.28 ± 29.76[1] CCT in ultrasound pachymetry and 532.42 ± 29.71[1] in AS-OCT, 80% power of test and 95% confidence level. Non-probability consecutive sampling was done. Total 108 patients with 54 in each group were required, so total 216 eyes with 108 eyes (both right and left in each group were evaluated. The inclusion criteria was age between 30-70 years, either gender and patients with refractive errors with no corneal abnormality. Exclusion criteria were patients with corneal scarring, Corneal trauma and patients with history of previous refractive surgery. Subjects of group A underwent acoustic Pachymetry while individuals of group B had anterior segment optical coherence tomography for measurement of central corneal thickness. We made two groups because it was difficult for the patients to undergo two different tests for the corneal thickness due to the financial constraints.

Patients attending the eye O.P.D and fulfilling the inclusion criteria were included in this study. Informed verbal consent was taken from all the patients and the information retrieved was collected on self-designed proforma. Central corneal thickness was measured using ultrasound pachymeters in group A and with anterior segment optical coherence tomography (Heidelberg) in group B. Both the procedures were done by an experienced ophthalmologist. Data was collected, compiled and analyzed using SPSS version 21. Gender was presented as frequency and percentages while variables like age, CCT on ultrasound pachymetry, CCT on anterior segment OCT were presented as mean ± SD. Mean central corneal thickness was compared between the two methods. Stratification was done on gender, age and post-stratification independent sample t-test was applied for mean difference CCT and P-value ≤ 0.05 was taken as significant.

RESULTS

One hundred and eight patients were equally divided into two groups. The mean age was 48.70 ± 7.82 years in group A and 50.66 ± 6.88 years in group B. In group A, there were 74.1% males and 25.9% females while in group B, there were 75.9% males and 24.1% females. Central corneal thickness of both groups is presented in Table-1.

Table 1: *Descriptive statistics of participants.*

	Group-A n = 54, 108 Eyes	Group-B n = 54, 108 Eyes
Age (Mean ± SD)	48.70 ± 7.82	50.66 ± 6.88
Gender		
Male	40 (74.1)	41 (75.9)
Female	14 (25.9)	13 (24.1)
Central Corneal Thickness (Mean ± SD)		
Right	532.09 ± 17.18	516.62 ± 18.25
Left	533.48 ± 16.33	514.53 ± 18.36

We found statistically highly significant difference between the mean central corneal thickness (532.09 ± 17.18 μm) of group A and group B (516.62 ± 18.25 μm) for right eye ($p < 0.001$). Similarly, we also found statistically significant difference between the mean central corneal thickness (533.48 ± 16.33 μm) of group A and group B (514.53 ± 18.36 μm)for the left eye ($p < 0.001$). Mean difference of central corneal thickness for right eye and left eye was noted as 15.46 ± 25.46 μm and 18.94 ± 25.52 μm respectively with p value of < 0.001.

Mean difference was also compared for stratified categories of gender and age group which are presented in Table – 3. We found statistically significant differences in central corneal thickness in two age groups (≤ 45 years and > 45 years). Central corneal thickness was more with pachymeters as compared to the AS-OCT (p value < 0.05).

Table 2: *Comparisons of measurement central corneal thickness in ultrasound pachymetry and anterior segment OCT.*

	Right Eye			Left Eye		
	Group – A (n = 54)	Group – B (n = 54)	P-value	Group – A (n = 54)	Group – B (n = 54)	P-value
Age						
≤45 years	533.54 ± 16.46	515.31±15.72	0.002*	533.40 ± 15.78	508.81 ± 18.14	< 0.001*
>45 years	531.09 ± 17.85	517.18±19.39	0.003*	533.53 ± 16.95	516.94 ± 18.14	< 0.001*
Gender						
Male	531.72 ± 18.50	516.14±19.37	< 0.001*	536. 6 ±16.07	517.24 ± 19.00	< 0.001*
Female	533.14 ± 14.06	506.00±13.46	0.010*	524.57 ± 14.06	506.00 ± 13.46	0.002*

DISCUSSION

Ultrasound pachymetry is thought to be a gold-standard approach to measure CCT. Several noncontact optical technologies such as anterior segment OCT has been introduced in the last decade. Corneal thickness plays an important role to determine corneal integrity.[9] It also helps in evaluating the endothelial pump function and to monitor the corneal diseases like Keratoconus and corneal oedema. It is also helpful in the selection of patients before refractive surgeries.[10,11] There is also a role of CCT measurement in the evaluation of contact lens wear and selection of patients with dry eye for therapy in clinical practice.[12,13]

Significant risk factor for progression of ocular hypertension to POAG can be evaluated by the measurement of CCT.[14,15] Intraocular Pressure (IOP) measurement by applanation tonometry is influenced by CCT which is a predictive factor for glaucoma progression. In patients with higher baseline IOP, CCT is measured and for that it is important to obtain the reliable corneal pachymetry and adjust the IOP accordingly to the measured CCT values.[16] There are numerous available methods to measure CCT. Ultrasound pachymetry is easy, fast, convenient and several measurements can be repeated to minimize error. It also has a high degree of inter-operator, intra-operator and inter-instrument reproducibility.[17]

Ultrasound pachymetry being a contact procedure, requires contact with the cornea and it uses Doppler Effect to measure the thickness.[12]AS-OCT devices are non-invasive and non-contact procedures, which rely on the principle of interferometry to detect minute differences in the depth of tissue.[15] They provide high resolution cross-sectional imaging of the both central and regional pachymetry of cornea. Anterior segment structures are also imaged along with sophisticated goniometry of the irido-corneal angle.[15]

Pentacam, Orbscan and AS-OCT are newer developed modalities which have widened the options and accuracy of measurement.

According to one study, AS-OCT values were lesser than the ultrasound values.[1] Several investigators who used Time Domain OCT (TD-OCT) had reported that ultrasound pachymetry gave

systematically higher values than that measured by TD–OCT.[15] In another study, there was a statistically significant difference between US pachymetry and AS-OCT, with US pachymetry measurements being consistently thicker. The authors suggested that CCT should be interpreted in the context of the instrument used.[18] According to Prospero Ponce CM et al,[19] Scheimpflug and OCT, CCT measurements were reproducible but always thinner than US pachymetry in normal and keratoconus-suspect eyes. However, in post-LASIK eyes, OCT pachymetry maps were more accurate than Scheimpflug maps. Li EY et al reported that anterior segment optical coherence tomography underestimated corneal thickness when compared with that measured with USP.[20] According to Zao, CCT with ultrasound pachymetry was highly correlated with the equivalent AS-OCT reading (The Pearson correlation coefficient = 0.93, P < .001). However, with Bland-Altman analysis it was shown that CCT measured by ultrasound pachymetry was significantly higher by 16.5 +/- 11.7 μm.[21]

In contrast to the above mentioned studies there is another research which has shown that measurement of CCT was in good correlation to the values obtained by UP.[22] In corneal edema, the difference between the two methods was increased, but continued to demonstrate excellent consistency. Chang SW et al, reported that the ultrasound CCT values were higher than the OCT values.[23]

With these differences in the studies, accuracy of corneal thickness measurements still remain unclear. It is also difficult to assess whether the two instruments took measurements from the same exact location. However, evidence suggests that, there is a systematic difference between OCT and ultrasound, which uses different hardware, software for analysis among the two modalities. There are also technique differences used by the individuals and placement of probe direction. Use of local anesthetic drops can lead to corneal edema as well.[24]

Theoretical explanations for the discrepancy would be that in ultrasound, the uncertainty of exact speed of sound as it passes between the corneal tissue can affect measurement of CCT.[15] Exact location of signal peak for the posterior reflection point in the ultrasound pachymetry remains unknown, it may be located between Descemet's membrane and anterior chamber of eye. This ambiguity in ultrasound measurement could be one the reasons for greater variations.

Small sample size was the limitation of our study. Other limitations of this study include a single-center experience and nonrandomized study design. The study was conducted among the urban environment therefore; results may not be generalizable to larger populations. In our study as we have divided the individuals into two groups so we couldn't evaluate the central corneal thickness in the same individual but among the two groups by both the instruments.

CONCLUSION

Central corneal thickness measurement by ultrasound pachymetry gives higher values as compared to AS-OCT measurement.

Ethical Approval

The study was approved by the Institutional review board/Ethical review board **(OSP-IRB/2021/005).**

Conflict of Interest

Authors declared no conflict of interest.

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Authors' Designation and Contribution

Waqas Ali; Resident: *Concepts, Design, Literature search, Manuscript preparation, Manuscript review.*

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Sahira Wasim; Resident: *Design, Literature search, Data acquisition, Data analysis, Statistical analysis, Manuscript preparation, Manuscript editing, Manuscript review.*

Ronak Afza; Resident: *Literature search, Data analysis, Statistical analysis, final review and approval*