Original Article

Thinnest Point of the Cornea Compared with the Central Corneal Thickness of Myopic Eyes Measured with Pentacam Scheimpflug System

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ABSTRACT

Purpose: Noncontact instruments like Pentacam Scheimpflug imaging allows assessment of corneal Pachymetry with good repeatability and reproducibility as compared to ultrasound. We aimed to differentiate corneal thinnest point and central corneal thickness on basis of magnitude and location, and its relation to age, sex, laterality, spherical equivalent and astigmatism in myopes.

Study Design: Correlational study.

Place and Duration of Study: Hashmani's Hospital Karachi from March 2021 to May 2021.

Methods: We enrolled 92 eyes (38 males, 54 females) of myopic adult patients from age 19-52 years. Pre-screening of myopes (-0.75DS to -8.00DS) included refraction, slit-lamp biomicroscopy and fundoscopy. Participants with ocular disease, previous ocular surgery, contact lens and history of any eye drops use were excluded from the study. Pentacam was used to determine CCT, thinnest corneal thickness (TCT) and vector location of TCT.

Results: Majority (77%) of the eyes had myopic astigmatism whereas 23% had simple myopia. We found statistically significant difference between CCT and TCT. Inferotemporal and inferonasal displacements of TCT were noted. No difference was noted between TCT and its location among the two sexes. We observed that alteration among the CCT and TCT in both age groups was statistically significant.

Conclusion: CCT and TCT are separate measurements and both are important since their magnitudes and locations might differ greatly especially with age. Both reading have significance in determining post-operative risk of corneal ectasia, assessment for refractive surgeries and early detection of ectatic conditions like keratoconus.

Key Words: Myopia, Pachymetry, Cornea, Central corneal thickness, Keratoconus, Refractive surgery.

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INTRODUCTION

Pachymetry has been used clinically for monitoring and diagnosis of diseases of cornea such as keratoconus and other types of corneal ectasia. Central corneal thickness (CCT) plays an important role in accurate measurement of intraocular pressure in Glaucoma as signified by Ocular Hypertension Treatment Study (OHTS).[1] OHTS also identified the relationship between the CCT and progression of glaucoma. It also helps in differentiation between entities like chronic open angle glaucoma, normal tension glaucoma, and ocular hypertension. Preoperative pachymetry is fundamental in planning corneal refractive surgery. Previously CCT has been taken as the thinnest region of central cornea for risk assessment of post-operative keractasia.[2] If thinnest

point of cornea is inadequately localized, measurement of only central corneal thickness can result in artificially larger corneal thickness (overestimation) thereby increasing risk of postoperative keractasia.[3-4]

Acoustic pachymetry has been the gold standard for measurement of corneal thickness but has limitations in placing correctly aligned probe manually over cornea as close as possible to the center of cornea which not only causes discomfort to the patient but hinders its reliability.[5] Noncontact instruments such as Pentacam Scheimpflug imaging allows assessment of corneal pachymetry with good repeatability and reproducibility.[6-8]

Limited research is available for comparison of TCT with CCT in myopic population in Pakistan. The aim of this study is to identify differences between corneal thinnest point and CCT in terms of scale and location and to analyze whether it is related to age, sex, laterality, spherical equivalent and astigmatism in myopic eyes.

METHODS

This cross-sectional study enrolled 92 eyes (38 male, 54 female) of myopic adult patients. The research was carried out at the Hashmanis Hospital Karachi from March, 2021 to May, 2021. This study followed the Declaration of Helsinki principles and the research was permitted by the Research Ethics Committee at Hashmanis Hospital. Inscribed informed consent was taken from every participant.

Prior to inclusion, all participants went through detailed ophthalmic examination which included refraction, slit-lamp biomicroscopy, fundoscopy and corneal topography. Exclusion criteria consisted of all detectable ocular disease, history of contact lens wear, history of ocular surgery, and use of eye drops.

The TCT and CCT and the site of thinnest point of cornea was obtained utilizing Pentacam (Oculus, Wetzlar, Germany software version). It utilizes a monochromatic slit-light source (blue light emitting diode at 475 nm), and consists of single rotating Scheimpflug camera that provides a 3-D scan of the anterior segment of eye. While scanning, the camera and source of light rotate simultaneously about the visual axis providing 25 slit images within 2 seconds. A second pupil camera detects eye movements which are automatically corrected through calculations.

All participants underwent Pentacam measurement for the assessment of corneal thickness performed through a fixed protocol during the scan. In accordance with the guidelines from manufacturer, the measurements were taken without dilatation in a dimly lit room. A fixed time of the day was selected from 10:00 to 17:00 hours to avoid diurnal variations in corneal thickness and shape. During scan of each participant, their head was well rested as per routine utilizing chin rest and forehead strap. The patients were asked to blink just before initiating the scan to ensure smooth even tear film over the surface of cornea. The participants were instructed to maintain their attention fixed on the blue fixation ring target while the observer changed the machine focus and alignment. The device takes three impressions of the pupil; at the corneal apex, the center, and the edge. The automatic release mode provided in Pentacam was employed to identify when the right alignment and focus to the corneal apex is reached. After that, the image was automatically taken. This was done to avoid operator bias. Only those scans were included in the analysis that showed "examination quality specifications" of "OK". For every participant, three consecutive readings were obtained and results were averaged for analysis and the same skilled operator conducted at least two corneal scans. Corneal thickness obtained included CCT, TCT and vector location of TCT. CCT was defined as the mean value of corneal thickness within 4mm central corneal area. TCT was defined as the thickness in mm of thinnest point on whole cornea, which was automatically determined by the machine. Vector location of TCT was measured in terms of horizontal (x-axis) and vertical (y-axis) shift of TCT from the corneal apex.

The autorefractometer AR-600A (Nidek, Gamagori, Japan) was used to obtain total objective refraction as it is known to have good validity and repeatability.[9]Myopia was defined as eyes having refractive error of <-0.5 diopter (D) spherical equivalent. Spherical equivalent of participants ranged from -0.75 D to -8.00 D with a mean of -4.56 ± 1.40 D. Participants were categorized in three groups on the basis of spherical evaluations; mild (-0.75DS to -2.75DS), moderate (-3.00DS to -5.75DS) and severe (≥-6.00DS). Additionally, participants having cylindrical refractive error of ≥ -1.00 diopter were considered as having myopic astigmatism, while participants who had cylindrical readings < -1.00 diopter were considered as simple Myope.

The data was analyzed using SPSS Version.23. Descriptive statistics were calculated. Unpaired t-test

Table 1: Descriptive statistics and refractive error of 92 myopic eyes.

Descriptive statistics		
Total Spherical equivalent in both eyes	-4.56 DS ± 1.40 D	Range of -0.75 D to -8.00 D
Spherical equivalent in right eyes	-4.73 ± 2.03 D	
Spherical equivalent in left eyes	-4.34 ± 2.56 D	
Refractive error		
Simple myopia	21 participants	23 percent
Myopic astigmatism	71 participants	77 percent
Categories of myopia		
Mild (-0.75 to -2.75 DS)	18 participants	20 percent
Moderate (-3.00 to -5.75DS)	50 participants	55 percent
Severe (≥ 6.00 DS)	23 participants	25 percent

Table 2: *Comparison of Average Thinnest Corneal Thickness, Central Corneal Thickness, and Displacement of Thinnest Corneal Thickness between Right and Left Eyes.*

Corneal topography parameters	Right Eyes	Left Eyes
Central corneal thickness	548 ± 24 µm (Range 492-598 µm)	550 ± 25 µm (Range 493-611 µm).
Thinnest corneal thickness	543 ± 29 µm (Range 490-594 µm)	547 ± 24 µm (Range 491-607 µm)
Displacement of Thinnest corneal thickness		
Inferotemporally	97.8%	95.7%
Inferonasally	2.2%	4.3%

and Kruskal-Wallis was used to compare mean for various groups of data and p-value of <0.05 was considered significant.

RESULTS

The study included 92 eyes (46 right and left eyes each). Thirty eight eyes belonged to males and 54 eyes belonged to females. Mean age was 26.93±6.82 years (range 19 to 52 years). The descriptive characteristics are listed in Table 1.

Table 2 shows average CCT, TCT and displacement of thinnest location. The mean difference between CCT and TCT in right eye and left eye was 4.63 ± 2.97 µm and 3.76 ± 2.16 respectively and this difference was significant in the paired t test(P<0.001).

The mean location of TCT of right eyes was 0.63 ± 0.18 µm temporally and 0.39 ± 0.23 inferiorly while in left eyes it was displaced 0.51 ± 0.23 µm temporally and 0.44 ± 0.24 µm inferiorly.

The mean thickness of the TCT in right eyes of both male and female participants was 543 ± 23. Meanwhile, in left eyes, the female participants displayed a mean thickness of 545 ± 23 µm whereas the male participants showed 550 ± 26 µm. In the t test (unpaired), this difference was not significant statistically (P=0.6). Moreover, the relationship of horizontal and vertical displacement of thinnest
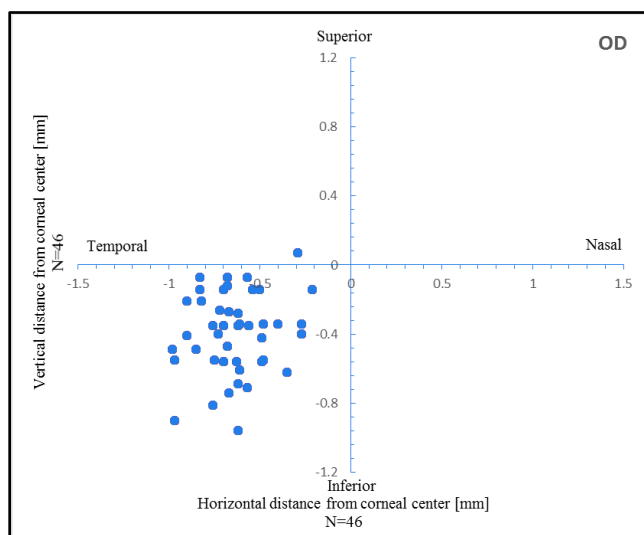

Figure 1: Location of the thinnest point of cornea (TCT) in right eyes.

corneal thickness among the two sexes was not did not show any significant differences in the unpaired t test for either of the eyes (P>0.05).

Average TCT was 545 ± 23µm and 545 ± 19 µmin participants of ≤ 25 and >25 years of age respectively. The mean variance between CCT and TCT was 4.72 ± 3.07 µm in participants of 25 and below and 3.71 ± 2.03 µm in participants above 25 years of age. These differences were statistically significant (P<0.001).
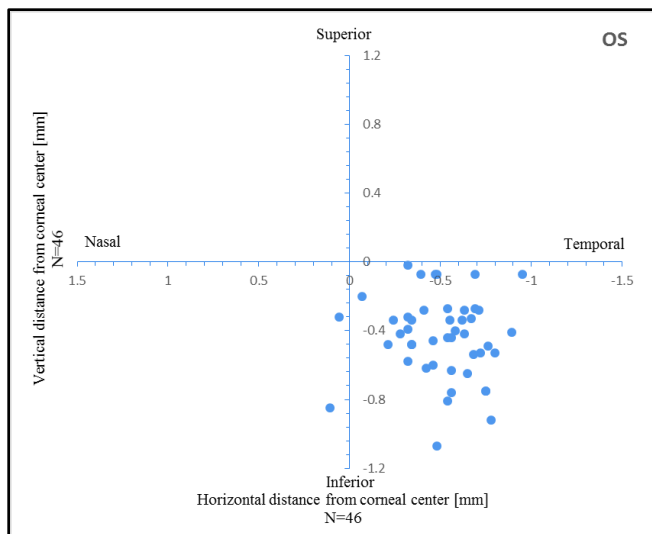
Figure 2: Location of the thinnest point of cornea (TCT) in left eyes.

Eighteen participants (20%) had mild myopia with thinnest point of 553 ± 14.7 µm. Fifty participants (55%) had moderate myopia with thinnest point of 543 ± 25.0 µm while 23 participants (25%) had severe myopia with thinnest point of 544 ± 28.1 µm. The Kruskal-Wallis test did not reveal these differences to be statistically significant in any category of myopia. There was no distinction between simple myopia and myopic astigmatism in terms of thinnest point.

DISCUSSION

Corneal thickness assessment with previous techniques such as ultrasonic pachymetry was considered gold standard in clinical practice however its limitation is lack of precise location of paracentral points in corneal thickness including measurement of thinnest corneal thickness point on cornea. This is attributed to pressure differences that produce variation in tear film displacement[5,10] or due to aberrant placement of probe that miscalculates the position of posterior corneal reflection point.[5,10,11]

The Pentacam uses a rotational Scheimpflug method to assess 25,000 elevation points and generates a 3-D map based on elevation data. It has superior inter-observer reproducibility than ultrasonic pachymetry.[11-13] Its reliability especially in terms of its consecutive measurements to obtain thickness at thinnest point centrally and the apex has been shown to be high.[13]

Previous studies and clinical practice have considered CCT as a determination factor in areas

such as Goldmann Applanation tonometry and for screening keratoectasia.[14,15] However, research on myopia has shown direct link between myopia progression and corneal thickness.[16-17] It has been stated that postoperative ectasia originates in the region of TCT which also has an established correlation of cone formation in keratoconus. Ashwin et al. found difference between TCT and CCT in both direction and magnitude to be 5.57 mm with TCT location displacing majorly in the inferotemporal quadrant.[18] Jin et al, compared corneal characteristics between high myopes and emmetropic controls to discover that overall corneal thickness at TCT and CCT was significantly thicker in emmetropes as compared to high myopes (CCT, 537.3 ± 34.3µm vs 530 ± 34.5µm; TCT 532.6 ± 33.4µm vs 525.7 ± 34.5µm).[19] Results seen by Al-Saif et al, showed significantly thinner pachymetry measurements in apical and thinnest point of cornea (P<0.005). However, they did not report any difference between simple myopic and myopic astigmatism group which was similar to our findings.[20]

We analyzed the scale of magnitude of thickness of cornea in two areas on cornea namely CCT and TCT in order to identify their difference and investigate its association with refractive error, age, sex and laterality. Our results showed that corneal thickness had nonlinear relationship with age, gender, laterality and refractive error. This implies that although there are significant differences that exist between CCT and TCT it is not influenced by any of the above-mentioned factors.

In our study, the mean difference among the TCT and CCT was 4.63 ± 2.97 µm in right eyes as compared to 3.76 ± 2.16 µm in left eyes. This result was similar to various studies conducted as well as international standards of corneal parameters.[21]The location of TCT in inferior temporal quadrant corresponds well with that of previous study.[20]

Various studies have demonstrated as the eye develops and grows there is change in CCT with age.[18-22] We found no such significant influence of age on CCT or TCT. The ratio of CCT to TCT remained unchanged with increasing age.

Refractive error has been shown to impact overall corneal characteristics due to increase in globe length which causes scleral thinning and subsequently stromal thinning as seen in myopia progression. Research suggests that about one third of high myopes have keratoconus or any other forms of corneal

ectasia.[23] In one study of keratoconus,[24] the TCT was found to be significantly thinner as compared to normal population. Demir et al,[25] considered TCT to be the most specific and sensitive marker for differentiating all stages of keratoconus from those of myopia. They concluded that the differences between CCT and TCT were significant in keratoconus stages I to III in the Amsler-Krumeich classification implied for early detection of disease and its progression. We did not find significant effects of refractive error on corneal pachymetry differences.

Our study had several limitations such as: a cross-sectional study and a single center study of myopes. Our conclusion may not be generalized for other racial groups/ethnicity/population. Majority of study included participants from younger age group so further research is required to examine corneal pachymetry changes in all ages.

CONCLUSION

In several areas of ophthalmology, pachymetry plays a vital and well-established role in the diagnosis, monitoring, and treatment of glaucoma and corneal disorders. Recognizing CCT and the thinnest corneal thickness (TCT) as separate measures is important since their magnitudes and locations might differ greatly especially with age. This study demonstrates the importance of measuring TCT along with CCT for determining post-operative risk of corneal ectasia, assessment for refractive surgeries and early detection of ectatic condition like keratoconus. The investigation of causal linkages behind observed differences in corneal thickness is constrained by the cross-sectional approach. Furthermore, since the study concentrated on a particular myopic population in a single hospital of Karachi, care is advised when extrapolating the results to larger populations.

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Patient's Consent: Researchers followed the guidelines set forth in the Declaration of Helsinki.

Conflict of Interest: Authors declared no conflict of interest.

Ethical Approval: The study was approved by the Institutional review board/Ethical review board **(2201/2219)**.

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Sharif Hashmani; Head of Department: *Concepts, Design, Data acquisition, Manuscript review.*

Nauman Hashmani; Consultant Ophthalmologist: *Concepts, Design, Data acquisition, Manuscript preparation Manuscript review.*

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