ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

To Study the Distribution of Corneal and Corneal Epithelial Thickness in Healthy Western Indian Eyes

Received: 26 October 2022, **Revised:** 28 November 2022, **Accepted:** 31 December 2022

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Keywords

corneal, epithelial thickness healthy eyes

Abstract

Aim: To evaluate the distribution of corneal as well as corneal epithelial thickness among competent western Indian eyes.

Material and Methods: The study was conducted in Western India at a tertiary care ophthalmology facility. Participants sought advice for refractive errors or laser refractive surgery as well as were healthy adults. Subjects underwent an intraocular pressure measurement with a noncontact tonometer, a slit-lamp examination of their eyes, a dilated pupil examination of their corneas, and a slit-lamp examination of their uveas. Exemption criteria included long-term topical medications, dry eye disease, being pregnant or nursing, and a background of wearing lenses during the previous four months. Data were only gathered from single eye of every participant, having the study eye getting selected by computer programme at random.

Results: Fifty eyeballs were collected from 50 participants, 23 (46%) of them were male and 27 (54%) were female. The ratio of left to right eyes was 24 to 26, or 48% to 52%. A sector-wise analysis did not indicate any significant link between the overall corneal thickness and epithelial thickness (all $P > 0.05$) except in the outer superior sector where there was a modest positive correlation ($r = 0.32$, $P = 0.03$). Nearly 11.9± 2% of total corneal thickness may be attributed to the epithelium, as measured by the mean epithelial thickness to corneal thickness (ET/CT) ratio of 0.13±0.01. ET/CT ratios ranged from 0.1 0.02 to 0.12± 0.07 ($P > 0.05$), with no significant difference between the lowest and greatest values.

Conclusion: We present the distribution of corneal epithelial as well as overall corneal thickness in healthful eyes in a predominantly Western Indian group and a correlation of such parameters between genders. As has been initially revealed in the literature, it was discovered that the distribution of epithelium really wasn't uniform throughout the seven mm region under study. There had been a distinct superior-inferior asymmetry, as well as the distribution of epithelium didn't appear to be strongly linked to the width of the underlying stroma.

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1. Introduction

The corneal epithelium is crucial for maintaining corneal regularity because of its rapid turnover rate as well as exceptional capacity for regeneration.[1 3] The epithelium has an impact on the cornea's refractive power, that ranges from 1.03 D in the middle two mm to 0.85 D in the outside 3.6 mm.[4] Hence, alterations in corneal epithelium width as well as distribution can both be responsible for refractive shocks following keratorefractive surgery as well as initial markers of corneal diseases like ectasia, dystrophy, as well as contact lens-associated keratopathy.[5 9] In order to enhance postoperative results, algorithms are getting established to anticipate "pre topographic" keratectasia as well as to tailor refractive procedures. Both of these techniques strongly depend on epithelial width profiles and their interactions with the underlying stroma.[5 10]

According to studies, Indian eyes often possess a thinner central cornea compared to Caucasian eyes. The prevalence of corneal epithelial width in Indian eyes has just recently been documented, and nothing is known about the characteristics of the epithelial as well as stromal distribution. [11 12] We examined the characteristics of corneal epithelial width as well as corneal thickness distribution throughout seven mm of the central cornea in healthy eyes from Western India using ultrafast spectraldomain optical coherence tomography.

2. Material and Methods

The study was conducted in Western India at a tertiary care ophthalmology facility. All subjects submitted their informed consent, as well as the institution's ethical review board authorised it. Subjects sought advice for refractive errors or laser refractive surgery as well as were healthy adults. They underwent an intraocular pressure measurement with a noncontact tonometer, a slit-lamp examination of their eyes, a dilated pupil examination of their corneas, and a slit-lamp examination of their uveas. Those showing corneal ectasia-related topographic patterns on the axial curvature maps produced by Schiempflug imaging with the Pentacam or with corneal ectasia-related clinical symptoms on slit-lamp biomicroscopy got disqualified.

Exemption criteria included long-term topical medications, dry eye disease, being pregnant or nursing, and a background of wearing lenses during the previous four months. Data were only gathered from single eye of every participant, having the study eye getting selected by computer programme at random.

3. Determining the Corneal and Epithelial Thickness

Ultrafast SD-OCT was used to evaluate corneal and epithelial thickness; the device used an 830 nm light source, scanned at a rate of 100,000 measurements per second, and had an axial resolution of 5 m and a transverse resolution of 12 m in tissue. The corneal topography was acquired in an average of 0.3 seconds utilising the "automatic capture" function of the "anterior, with adapter, topography OCT (TOCT) module." The "TOCT" module generates maps of the cornea's total thickness (stroma plus epithelium) as well as the thickness of its epithelium. Only those measurements with a high enough acquisition quality (marked with a green

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checkmark by the machine) were included in the final statistical analysis.

Data output included the option to show average, minimum, and maximum thickness in 17 sectors across three zones, covering the cornea and epithelium thickness profiles across the centre 7 mm: First, there's the 0-2 mm core, then there's the 2–5 mm inner ring/ring 1 with its eight distinct sectors (superior [S], inferior [I], nasal [N], temporal [T], superonasal [SN], inferonasal [IN], superotemporal [ST], and inferotemporal [IT]), and finally, there's the 5–7 mm outer ring/ring 2 with its eight distinctive sectors.

The OCT device's built-in software provides eight parameters for the cornea and epithelium (micrometres) automatically: Thicknesses measured at I the centre, (ii) a minimum of 7 mm, (iii) a maximum of 7 mm, (iv) a minimum of 7 mm and a maximum of 7 mm, (v) the SN/IT interface, (vi) the S/I interface, (vii) the ST/IN interface, and (viii) the T/N interface, all at 5 mm. Each patient's value was put into an Excel sheet, and the mean was then determined [Table 1]. As the difference in the radially opposite sectors of the midperiphery, that is, 5–7-mm zone, is not presented by the automated programme, as an extra step, using the “average thickness” display option, the corneal and epithelial thickness was reported for all patients in each of the 17 segments. After averaging the data in the relevant sectors for each patient and subtracting the resulting averages, the mean corneal and epithelial thickness differences of the radially opposite sectors were computed [Table 2].

4. Analyses of Statistics

SPSS Statistics, a commercially accessible programme, was used for the statistical analysis (version 25.0). Descriptive statistics for continuous data were presented as mean ± standard deviation. These are the unrelated samples. Comparing corneal and epithelial thickness between sexes and in radially opposite corneal sections was done using the Student's t test. Epithelial thickness and corneal thickness were correlated using Pearson's correlation coefficient. Where $P<0.05$, it was regarded to be significant.

5. Results

Fifty eyeballs were collected from 50 participants, 23 (46%) of them were male and 27 (54%) were female. The ratio of left to right eyes was 24 to 26, or 48% to 52%. The mean age and manifest refractive spherical equivalent (MRSE) were 24.98 ± 3.63 years and −2.49 ± 2.53 D, respectively. The mean simulated keratometry (Km) and maximum keratometry (Kmax) as recorded on the Pentacam were 44.21± 2.01 D and 45.11 ± 2.22 D respectively.

6. Thickness of the cornea and the epithelium, by sector

A sector-wise analysis did not indicate any significant link between the overall corneal thickness and epithelial thickness (all $P > 0.05$) except in the outer superior sector where there was a modest positive correlation ($r = 0.32$, $P = 0.03$). Nearly 11.9± 2% of total corneal thickness may be attributed to the epithelium, as measured by the mean epithelial thickness to corneal thickness (ET/CT) ratio of 0.13±0.01. ET/CT ratios ranged from 0.1 0.02 to 0.12± 0.07 ($P > 0.05$), with no significant

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difference between the lowest and greatest values.

Table 1: Epithelial and corneal thickness profile obtained from measurements taken with the Revo Nx spectral-domain OCT and shown in-built software.

	Corneal thickness (µm)	Epithelial thickness (µm)
Central thickness (µm)	506.58±12.58	59.97 ± 4.69
Minimum thickness (µm) [7 mm]	496.85±15.25	38.02±6.63
Maximum thickness (µm) [7 mm]	591.69±12.69	107.82±22.36
Minimum- maximum thickness (µm) [7 mm]	−79.89±8.96	−56.97±8.88
SN- IT cornea (µm) [5 mm]	29.36±9.87	−1.81±2.36
S-I cornea (µm) [5 mm]	22.99±6.34	−6.03±2.63
ST- IN cornea (µm) [5 mm]	2.79±16.92	−2.74 ± 4.25
T- N cornea (µm) [5 mm]	−24.01±14.58	−1.33±1.22

The average values of the parameters provided by the machine's internal software are shown in Table 1, while the average differences between the radially opposite sectors of Ring 1 (2-5 mm) and Ring 2 (5-7 mm) are shown in Table 2. These differences were determined by taking note of the values in each of the 16 sectors using the "average thickness" display option for each patient, and then subtracting the means. Corneal thickness was considerably greater in the paracentral 2-5 m (ring 1) and midperipheral 5-7 m (ring 2) zones than in the radially adjacent inferotemporal [IT], inferior [I], and temporal [T] sectors, as shown in Table 2.

Table 2: Estimated average radial disparities in corneal and epithelial thicknesses from measurements taken in each of the 16 sectors for each subject.

Zone	Sector difference	Corneal thickness difference (µm)	P-value	Epithelial thickness difference (µm)	P-value
Inner Ring (2-5 mm)	SN- IT cornea (µm)	27.99±7.78	<0.001	−1.03±5.38	0.22
	S-I cornea (µm)	25.01±6.39	<0.001	−5.02 ± 1.63	0.001
	ST- IN cornea (µm)	5.42±1.33	0.21	−3.99 ± 1.11	0.01
	T- N cornea (µm)	−16.25±5.52	0.005	−0.17± 2.52	0.74
Outer Ring (5-7 mm)	SN- IT cornea (µm)	50.25±8.66	<0.001	−3.99 ± 2.58	0.32
	S-I cornea (µm)	47.01±8.73	<0.001	−7.52±2.07	0.03
	ST- IN cornea (µm)	9.99±3.32	0.06	−4.12±1.41	0.22
	T- N cornea (µm)	−27.01±4.52	<0.001	0.6±1.13	2.2

In ring 1, the epithelium was found to be substantially thinner in the superior [S] and

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ISSN: 2309-6152 (Online)
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supero temporal [ST] sectors compared to the diametrically opposed inferior [I] ($P< 0.001$) and inferonasal [IN] ($P <0.01$) sectors. In the mid peripheral zone, that is, ring 2, a significant variation in epithelial thickness was found only in the vertical meridian, with the superior [S] epithelium being thinner than the inferior ($P = 0.02$).

In contrast, the least epithelial thickness in a majority of the eyes (52%) was identified in the superior area. The mean central and average epithelial thickness across the 7-mm region for men was 59.98±5.85 µm and 57.88±7.85 µm, respectively. In females, the average epithelial thickness in the central 7 mm zone was 55.79± 4.91 m, and the central epithelial thickness was 59.85± 4.87 m. The central and average epithelial thickness was statistically equivalent across genders ($P=0.74$and $P=0.3$, respectively). The epithelium was thicker in men in all the sectors as compared to females, albeit the difference did not attain statistical significance in any of the sectors.

7. Discussion

The central corneal epithelial width of healthy eyes has readings from 48.5 to 59.9 micrometres, according to the research.[13 21] The average central epithelial width measured in our subjects had been 59.97 ±4.69 m, which was at the upper end of this range as well as comparable to values of 58.4 ±2.5, 59.9 ±5.9, as well as 57.4 ±7.7 m recorded in previous ASOCT-based analyses by other authors.[14 15 19] The somewhat broad variation in central epithelial width reported in numerous publications might be caused by variations in the technology adopted to quantify epithelial width or various modalities of data collection employing the same method. [18 21] Outcomes for central epithelial width could still differ significantly between studies despite after potential confounders have been taken into account. For instance, Hoshing et al.[12] as well as Hashmani et al.[22] from western India as well as the western region of the Indian subcontinent, accordingly, concluded actually imply central epithelial width of fifty four and 53.9 m, respectively, whereas the central epithelial width in our predominantly Western Indian population was approximately six m thicker. We obtained outcomes that were in line with those of earlier research employing SDOCT with an axial resolution of five m in tissue as well as automated data collection using built-in software. [12 22]

These factors may be highly important in India. Ex vivo investigations have demonstrated that latitude and background radiation have an impact on the width of the human corneal epithelium.[23] According to studies on healthy eyes, there might be topographic diversity within the eye, having the epithelium generally being thinner superiorly as well as temporally versus inferiorly as well as nasally. This is due to the fact that a constant corneal power as well as visual refraction in a person over time requires the central as well as paracentral epithelium to preserve a reasonably consistent profile.[21 24 26] The superior as well as superotemporal sections of the two to five mm zone in our subjects were smaller than their radially opposite inferior as well as inferonasal counterparts, estimating 5.02±1.63 and 3.99±1.11 m narrower accordingly [Table 2].

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This variation was greater than the 2.36 and 2.77 m in superior epithelium thickness that Hoshing et al.12 mentioned for the right as well as left eyes, correspondingly, in the two to five mm zone in Indian subjects, although it was comparable to the 5.7 m in superior epithelium thickness that Reinstein et al.[2] documented for a three mm zone. Epithelial thinning in such regions has been associated with a number of factors, including the frictional forces generated by the upper lid during blinking, the higher placement of the outer canthus contrasted to the inner canthus, the gravitational influence, as well as a smaller contact duration of the tear film in the superior meridian, that results in less lubrication and/or nourishing impacts.[22 27]

For the radially opposed sectors in ring 1, Table 1 presents the TN as well as STIN discrepancies in epithelial width to be -1.33±1.22 as well as -2.74±4.25 m, correspondingly, while Table 2 displays them to be -0.17±2.52 as well as -3.99±2.58 m, respectively. Such inconsistencies are explained by the data collection and analysis methodologies utilised: Table 2 presents information retrieved by independently estimating the means in every sector and afterwards subtraction of the subsequent means of radially opposite sectors. Table 1 displays the means gathered by averaging values depicted by built-in software. We contend that Table 2 provides a more realistic representation of the distribution characteristics of the epithelium versus Table 1, since Table 1 employs a method known as "averaging the averages," which involves averaging data which is generated automatically via the SDOCT application.

The majority of the cases in our investigation had the thinnest epithelium just above jaw as well as the narrowest pachymetry underneath, but we were unable to identify any sectoral or zonal associations among the two. Such results support the hypothesis that the rate of variation in epithelial width depends on the curves of the surface rather than the width of the stroma beneath it. This notion is supported by Wang et al.[20]'s discovery that epithelial width as well as stromal width are positively correlated solely in keratoconic eyes however not in healthy eyes. Hence, rather than the underlying stromal width, the anatomical as well as physiologic factors related to blinking as well as tear film dynamics are much more expected to influence the topographic diversity of the epithelium in healthy eyes.

Males mean epithelial width was discovered to be 1.91 m larger than women's, having the discrepancy exceeding Two m in thirteen of the sixteen investigated locations. These results were in agreement with Hashmani et al.[22] as well as Kanellopoulos et al.[25], who also discovered thicker epithelium in all men, having the disparity per sector ranging from 0.7 to 2.9 m for the former as well as from 1.31 and 2.21 m for the latter[25]. Wu et al. found that men's epithelial width was 1.31 micrometres larger than women's.[24] The gender-based width discrepancies were numerically noteworthy for the aforementioned investigations, however not for our group, although having identical magnitudes. This is probably due to the smaller sample size in our research. [24 25]

The study's limitations are acknowledged by the authors, who also acknowledge the research's small sample size, the subjects' limited range of ages, that precluded a side-by-side correlation of epithelial attributes by age, as well as the incapacity to assess epithelial dispersion features above seven mm. Earlier research has shown that SDOCT can accurately measure epithelial width, and whilst this wasn't examined in the current study, it is probable that the outcomes will be the same.[25 27] The ultrafast scanning rate of the SDOCT gadget utilized must minimise alterations brought about by spontaneous ocular motions as well as the thinning/breakup & evaporation of the tear film when combined with a very brief picture capturing time of 0.3 seconds.

8. Conclusion

In conclusion, we provide a primarily Western Indian cohort's distribution of corneal epithelial and total corneal thickness in healthy eyes, as well as a comparison of these parameters across sexes. Epithelial distribution was found to be non-uniform across the 7 mm region investigated, as has previously been reported in the literature; there was a clear superior-inferior asymmetry, and the distribution of epithelium did not seem to be correlated with the thickness of the underlying stroma. The thickness of the central epithelium was 59.97±4.69 m, which was around 6 m larger than the most recent data from the western portion of India. Confirming or refuting these differences is recommended for fully "customising" diagnostic or therapeutic algorithms based on corneal epithelial thickness for our community, which would need more research with a bigger sample size.

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