Original article:

Central and peripheral corneal thickness in Malays and its variation with age

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Abstract

Background: Corneal thickness (CT) is an important parameter in refractive surgery but available data is scanty on corneal thickness of normal Malays. The purpose of this study is to determine central and peripheral CT in a sample of Malays and find its effect on age. ***Methods:*** Seventy–two (72) participants were invited to participate in this study. Their age ranged from 15 to 65 years old. CT was measured using an ultrasonic pachometer (Corneo-Gage TM Plus2) at 5 different locations namely central, superior, temporal, inferior and nasal regions of the cornea. A total of three readings were taken for each location of the cornea and the mean was calculated. CT was presented as total, epithelial and stromal thickness for three age groups, namely <20years, 21-40years and >40 years for comparison. ***Results:*** Mean value for central CT for Malays was 597.9 ± 35.2 μm and peripheral CT was significantly thicker than the centre at all locations. There was significant thinning in CT as age advanced at all locations except at the centre. The epithelial layers do not show any changes with respect to location and age which implied that changes in CT at different location and as results of advancing age were mainly due to the stroma. ***Conclusion:*** The values of CT in normal Malays was 597.9 ± 35.2 μm and CT was thinnest at the central region. Except at the central region CT decreased with advancing age. These values can be a suitable reference when planning for refractive surgery and penetrating keratoplasty among Malays.

Keywords: corneal thickness; age; Malays; stromal thickness; ultrasound pachymetry

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Introduction

Corneal thickness (CT) is an important indicator of corneal health status. Measurements of CT are used to obtain information about physiological and clinical conditions of the cornea. Antero-posterior corneal swelling for instance directly reflects a state of hypoxic stress especially in extended contact lens wearers. Intra ocular pressure (IOP) calculation using Goldman applanation tonometry (GAT), which assumes central CT to be 520 μm, could result in IOP underestimation in thinner corneas. Its important role in refractive surgery is also undeniable. CT is an essential biometry measurement in pre-refractive surgery examination. With more people undergoing refractive surgery, accurate corneal CT measurement may prevent post-surgical corneal ectasia as CT may be reduced significantly.

In a general population CT is related to many demographic and ocular factors, which include age, gender and ethnicity. In a review of 300 data sets by Doughty & Zaman[1], the mean central CT using ultrasound was 544 ± 34 μm. Most of the differences in mean central CT reported between different studies were thought to be due to different tools of measurements and age groups studied. Differences in results were also reported regarding CT in the central and peripheral regions, with some reporting CT was thicker at the periphery[2,3] no difference[4], whilst other

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showed peripheral cornea to be thinner than the central region[5,6].

Whilst many of the studies on central CT were done on the western populations, there were some that examined corneal changes in the eastern populations. Tomidokoro et al.[7] found the mean central CT obtained in a Japanese population was associated significantly with corneal curvature but not with age. Lee et al.[8] also found no significant difference in CT in a sample of Korean with respect to age except for the 20-26 year-old age group. Earlier studies[2,5-6,9-11] and recently Hoffman et al.[12] reported no significant difference in central CT with age, contrary to other studies[13-17] that observed thinning of central CT as age advanced. Doughty & Zaman[1] surmised that age had no obvious impact on corneal CT measures for whites, but an age-related decline in central CT was evident for non-whites. In summary results of variations in CT and age were seen contradictory with some showing no differences and others showing a decrease in CT as age advanced.

Alsbirk[18] observed a highly significant ethnic difference in male Eskimos compared to Danes. Danes showed no significant difference as age increased but for adult male Eskimos, central CT decreased with age. Shimmyo et al.[19] reported that African Americans had significantly thinner central CT than Caucasians, Asians, or Hispanics. Past studies [5,11,13,20,21] have shown that other factors may affect the measurement of CT including refractive errors, length of the eyeball, systemic diseases and intraocular pressure but with conflicting results. A study on Singapore Malay population[21] showed central CT was greater in individuals with greater intraocular pressure (IOP) ($P < 0.001$), greater axial length ($P = 0.005$), and greater radius of corneal curvature ($P < 0.001$). However Mohd-Ali et al.[22] and Mostafa[23] found no association between central CT and corneal curvature.

To our knowledge, few data on CT in Malays have been reported. We aim to report CT in Malays at the central and four peripheral locations and to determine if central CT is significantly different from its peripheral locations. We also aim to determine CT changes with age.

Methods

A total of 72 participants (40 females and 32 males) were invited and consented to participate in the study. Human ethical committee approval from Universiti Kebangsaan Malaysia (UKM) was obtained prior to the study. Parental consent was obtained in participants less than 18 years of age. Participants comprised of UKM staff and family members, students and patients from the optometry clinic.

Inclusion criteria for the study were healthy participants free from ocular and systemic diseases such as glaucoma or diabetes mellitus. However older participants who had hypertension of less than 3 year's duration were accepted into the study. Refractive errors were limited to ±3.00D spherical and 1.00DC cylindrical component respectively. Contact lens wearers were excluded from the study.

CT measurement was done using an ultrasonic pachometer (Corneo-Gage TM Plus2, Sonogage, Japan). The instrument can be set to measure total and stromal thickness. After a brief explanation to the subject, a drop of anaesthetic (Benoxinate Hydrochloride 0.4%) was instilled into the subject's right eye. Sensitivity of the cornea was tested using cotton wool before measurement was taken. Measurement was done for the right eye only. For central CT measurement participants were seated comfortably and asked to look at a marked location on the wall in a straight ahead primary position. For peripheral measurements participants were asked to look at pre-marked targets on the wall at four different locations namely superior, temporal, inferior and nasal positions. The position of the probe was close to the limbus for peripheral measurements. Ultrasonic pachometer was set to give 3 automatic digital readings of CT for each location when the probe was in correct position (within 10 degree range perpendicular to the corneal surface). Pantasept was used to clean the probe upon completion of measurement. At the end of the procedure a slit lamp examination was done with fluorescein on the cornea to ensure there was no untoward damage done to the cornea during measurements. All measurements were carried out between 9.00am to 1.00pm to minimize the effect of diurnal variation.

Shapiro- Wilkes test was used to determine whether the data was normally distributed. Since the data was normally distributed, values were given as mean ± standard deviation, and significance was tested by one-way analysis of variance (ANOVA). The level of significance chosen was 0.05. Data was analysed to examine changes according to age and also for different locations of the cornea. To analyse changes with age, participants were arbitrarily divided into 3 age groups for comparison, namely <20years, 21-40years and >40 years. We also categorised corneal thickness into the epithelial and stromal layers and observed its changes with age.

Results

Altogether 72 participants took part in the study, comprised of 40 females (55.6%) and 32 (44.45) males. Their age group ranged from 5 to 65 years. There were 12 participants (6 males, 6 females) in the 1-20 year-old age group followed by 31 (18 females, 13 males) in the 21-40 year-old and 29 (16 females, 13 males) in the above 40 year-old age group respectively.

The results for the overall CT were depicted in Table 1. Mean CT for the central region was 597.9 ± 35.2 µm followed by 722.7 ±50.6 µm, 757.5 ± 54.7 µm, 768.0 ± 52.2 µm, 758 ± 58.0 µm in the superior, temporal, inferior and nasal region respectively. Analysis of variance (ANOVA) showed significant differences between the centre and all the different locations of the cornea (P<0.05). CT gets increasingly thicker towards the periphery.

With regard to age, ANOVA showed significant differences between the younger (<20 year-old) and older (>40 year-old) age groups for all the different locations of the cornea except at the central region. There were significant differences between the 21-40 year-old and >40 year-old age groups at the temporal, inferior and nasal regions, and between the <20 year-old and 21-40 year-old age group there were significant differences only at the temporal and nasal regions.

Table 1 Mean corneal thicknesses and age groups at different locations of the retina

Age (years) / location	Central (µm)	Superior (µm)	Temporal (µm)	Inferior (µm)	Nasal (µm)
< 20	612.0± 27.0	750.8 ± 35.3	817.8 ± 48.7	806.4 ± 52.5	811.4 ± 47.2
20 - 40	601.4 ± 34.6	727.0 ± 51.1	**759.7 ± 39.2	778.2± 43.1	**767.6 ± 46.5
≥ 40	588.3 ± 37.0	*706.4 ± 50.9	§*730.1 ± 51.7	§*741.2 ± 48.4	§*725.6 ± 54.0
Overall	597.9 ± 35.2	722.7 ±50.6	757.5 ± 54.7	768.0 ± 52.2	758 ± 58.0

§*P<0.05

Data are presented as mean ± standard deviation

*indicates significant differences between the age group and < 20 years-old group.

§indicates significant differences between the age group and 21-40 years-old group

**indicates significant differences between the age group and < 20 years-old group.

Independent sample t-test showed no significant differences between males (N=32) and females (N=40) in this study (P>0.05).

We have also separated CT into the stromal and epithelial layers and repeated the above analysis. Table 1 and Figure 1 showed epithelial thickness at different locations of the cornea. ANOVA showed no significant differences in epithelial thickness in all central, superior, temporal, inferior and nasal cornea respectively with increasing age (p>0.05).

Table 2 Mean central and peripheral epithelial thickness ± SD (µm) at different locations in different age groups.

Age (years) /location (micron)	Central	Superior	Temporal	Inferior	Nasal
≤ 20	65.5 ± 3.2	61.4 ± 3.0	61.7 ± 3.2	62.5 ± 3.4	60.0 ± 3.0
20 - 40	65.0 ± 4.1	61.2 ± 2.7	62.4 ± 4.3	61.9 ± 3.5	61.3 ± 3.9
≥ 40	63.9 ± 4.4	61.3 ± 3.7	61.3 ± 3.5	60.9 ± 3.0	61.3 ± 2.9
Overall	64.7 ± 4.1	61.3 ±3.2	61.9 ± 3.8	61.6 ± 3.2	61.1 ± 3.4

Table 3 and Figure 2 showed stromal thickness at different locations of the cornea for all age groups. ANOVA showed significant differences between stromal thickness for different locations of the cornea (P<0.05). Post hoc results showed that except for the centre, stromal thickness was thinner for the >40 year-old age group at all location compared to the <20 year-old age group. It was also thinner at the

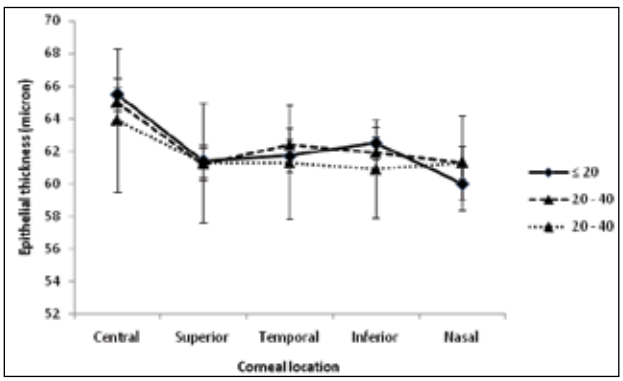

Figure 1: Epithelial thickness at different location according to age group

temporal, inferior and nasal region compared to the 21-40 year-old age group. The temporal and nasal stroma of the 21-40 year-old was also thinner compared to the <20 year-old age group.

Table 3 Mean central and peripheral stromal thickness ± SD (μm) at different locations in different age groups.

	central	superior	temporal	inferior	nasal
≤ 20 years	546.5 ± 25.6	689.4 ± 35.9	756.1 ± 49.5	743.9 ± 53.4	751.3 ± 47.5
21-40 years	536 .3± 34.1	665.7 ± 51.5	**697.2 ± 38.9	716.3 ± 43.0	**706.3 ± 46.0
>40 years	524.3 ± 35.8	*645.1 ± 50.0	§*668.8 ± 52.7	§*680.3 ± 48.4	§*664.3 ± 54.2
Overall	533.2 ± 34.2	661.4 ± 50.5	695.6 ± 55.0	706.4 ± 52.0	697 ± 58.1

Data are presented as mean ± standard deviation

*indicates significant differences between the age group and < 20 years-old group.

§indicates significant differences between the age group and 21-40 years-old group

**indicates significant differences between the age group and < 20 years-old group.

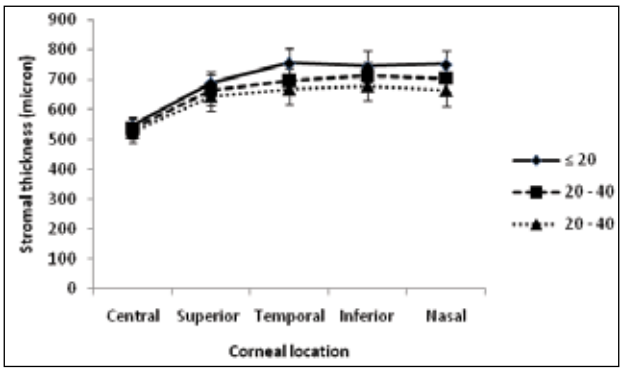

Figure 2 Stromal thickness at different location according to different age group

Discussion

This study examined CT in different locations in a sample of Malays and its changes with age. Our results showed that CT become increasingly thicker towards the periphery and also decreased in thickness as age advanced. The mean central CT among Malays in this study was found to be 597.9 ± 35.2 μm, which is almost similar to the study by Mohd-Ali et al.[23] who found mean central CT of 596.03 ± 45.67 μm in a group of young Malaysian adults with mean age of 21.42 ± 1.47 years.

CT has been shown to differ with ethnicities. Compared to many other studies on central CT, the mean CT for the Malays seemed higher than other ethnicities reported previously. Iyamu & Osuobeni[16] for example, showed the mean central CT for Nigerian was 548.97 ± 34.28 μm and Galgaukas et al.[17] gave a value of 544 ± 30.5 μm for adult Lithuanian population. Mostafa[24] reported mean central CT of 530.06 ± 38.03 μm for Egyptians. In Hong Kong Chinese and Taiwanese values of 560.8 ± 34.4 μm and 533.00 ± 29.00 μm were reported by Lam & Douthwaite[14] and Chang et al.[25] respectively. Mohd-Ali et al.[23] also showed significant differences between central CT of Malays and Chinese in their sample, the central CT of Malays was higher compared to the Chinese. In contrast Tong et al.[26] found a significantly higher values of central CT in Chinese compared to Malays and Indians in their sample of 9-11 year-old schoolchildren in Singapore. However some of the differences could be due to differences in tools of measurement and different age groups. Although the number of participants in our study was not large we have selected almost equal number of participants in the different age groups for this study.

Our study showed significant differences in CT between the centre and at all the different locations of the cornea. Relatively the thickest section was in the inferior section (768.0 ± 52.2 μm) followed by both the nasal (758 ± 58.0 μm) and temporal sections (757.5 ± 54.7 μm). Mohd-Ali et al.[23] also showed similar trend whereby CT were relatively thicker at the peripheral locations relative to the centre. The results of this study was in agreement with many studies reported previously that showed CT being significantly thicker at the periphery compared to the centre[2,3]. However studies by Kremer et al.[6] and Edmund[27] found the peripheral cornea to be thinner than the central region.

With regard to age group our study showed significant decrease in CT as age advanced. There were significant differences in CT between the young (<20 year-old) age group compared to the older (>40 year-old) age group for all locations. There were also significant differences in CT between the <20 year-old age group and the 20-40 year-old age groups at the nasal and temporal locations. The decrease of CT with age is also consistent with many other studies reported previously. Lam & Douthwaite[14] studied 240 Chinese population in Hong Kong reported general thinning at central and four peripheral regions as age advanced. Similarly Foster et al.[13] observed significant decrease in central CT with age in their 1242 Mongolian participants. This trend

had been demonstrated in other western population-based studies. The results re-emphasize that CT is asymmetric and undergo age-related anatomical changes. The decrease of CT with age has been attributed to decline of density of keratocytes and probable breakdown of collagen fibres in the ageing cornea.

The instrument used in this study enabled us to calculate the epithelial and stromal thickness of the cornea and compared them across different locations with advancing age. It is known that the epithelium contributes only about 10% of the total thickness of the cornea which was also found in this study. The epithelial thickness however showed no significant differences at all locations and also with an increase in age. Stromal thickness across different locations and different age groups however showed similar changes found in total corneal thickness with regard to locations and age. Ours results implied that the stromal layer was the major contributor in determining the overall CT.

There was no significant difference in CT between genders, which was also found in many other studies[1]. We did not measure intraocular pressure due to time constraints. Indeed intra ocular pressure has been shown to be correlated to CT[28] and it was found to be thinner in high myopia[29]. We have limited our participants to those with power ±3.00DS or less and cylindrical component of not more than 1.00DC to avoid the influence of refractive error on the CT measured. Presence of arcus senilis in elderly participants may also affect peripheral CT measurements but it was previously reported[5] that this lipid layer actually did not influence the reading of CT.

Other factors that could affect the value of CT, such as pregnant women, contact lenses wearers, participants with systemic disease and those with corneal pathology were excluded from this study. It was reported that central CT was higher in patients with diabetes[30]. In addition, contact lens users also often experienced corneal hypoxia which could result in corneal swelling. The limitation in our study included the small number of participants which could affect results.

Conclusion

In conclusion the mean CCT for Malays was 597.9 ± 35.2 μm and there was no significant difference between males and females found in this study. CT was thinner at the centre compared to the periphery. With the exception at the central region, there was significant thinning in corneal thickness at the peripheral locations as age advanced. The epithelial layer did not show any significant changes with age.

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