RETINAL AND CHOROIDAL THICKNESS IN MYOPIC AND EMMETROPIC MALAY SUBJECTS

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ABSTRACT

Introduction: The elongation of eyeball which led to the increment of refractive error can cause pathological effects on the fundus. This is can be seen in myopic groups as their eyeballs are elongating which then affect the thickness of choroid and retina. The choroidal thickness (CT) and retina retinal thickness is highly influenced by refractive error. Depending on the refractive errors, some thinning areas of the choroid and retinal thickness would be varied. **Aim:** This study was carried out to assess the differences in retinal and choroidal thickness among myopic groups and emmetropic Malay subjects**. Methodology:** In this clinical cross-sectional study, 46 subjects (aged 19 to 24) with mean SER values of -0.10 ± 0.25 D for emmetrope, -1.69 ± 0.60 D for low myope, -3.92 ± 0.86 D for moderate myope, and -6.17 ± 0.63 D for high myope were examined. The retinal and choroidal thickness of the outer (perifovea) and inner (parafovea) macular layers at four separate locations, including the temporal, superior, nasal, and inferior quadrants, as well as the fovea itself, were measured using swept source optical coherence tomography (SS-OCT). **Results**: There were no significant inter-group differences in the foveal thickness and in the thickness of all the inner rings of the macula ($p > 0.05$). However, there were significant differences in the mean outer CT between the myopic groups and the emmetropes at the nasal quadrant ($F(3,43 = 6.15$, $p < 0.05$) and the inferior quadrant ($F(3,43) = 3.84$, $p < 0.05$). When compared to the emmetropic group, a Dunnet post-hoc test revealed that the outer CT in the nasal area was reduced in the low, moderate, and high myopia groups. In addition, compared to the emmetropic groups, the low and moderate myopia group had a reduced outer CT at the inferior region. **Conclusion:**

There are differences of CT between emmetropic and myopic Malay subjects however the retinal thickness does not vary.

KEYWORDS: choroidal thickness, retinal thickness, myopia, swept-source optical coherence tomography

INTRODUCTION

Myopia, a common refractive error, is impacting an increasing number of people. Myopia progression can lead to a variety of significant consequences, including blindness (Xiang & Zou, 2020). Holden et al. estimated in 2016 that 1.406 billion people (22.9 percent of the global population) had high myopia in 2000, and that 163 million people had high myopia in 2000. They also estimated that by 2050, there will be 4.758 billion persons with myopia (49.8% of the world's population), with 938 million of them having high myopia. This is a concerning figure, and more studies are required to determine how the increase in refractive error produced by the elongation of the eyeball affects the thickness of retina and choroid. Rudnicka et al. (2015) disclosed the differences in myopia prevalence based on ethnicity, age, environment, and gender in 2015. Myopia, for example, is most common in East Asians, and at the age of 10, the incidence was already 35%. At the age of 18, the incidence was as high as 80% in East Asians, while it was less common in Caucasians (23%) and black Africans (6%). Children in cities have a 2.6-fold higher chance of acquiring myopia than children in rural areas, while girls appear to have a 2-fold higher risk of developing myopia than boys, at least in Caucasians and East Asians.

This indicates that the solution for halting myopia progression should be implemented as soon as possible. One of the reasons to halt the myopia progression is pathological myopia. According to Ohno-Matsui et al. (2021), high myopia is defined by a high degree of myopic refractive error, whereas pathologic myopia is defined by the presence of typical fundus complications such as posterior staphyloma or myopic maculopathy that is equal to or more serious than diffuse choroidal atrophy. Although pathologic myopia is more common in eyes with high myopia, its repercussions, particularly posterior staphyloma, can occur in eyes with low and moderate myopia. Furthermore, the increase in refractive error is linked to the elongation of the eyeball, which affects the thickness of the retina and choroid. Therefore, this study was carried out to determine whether there were any differences between CT and retinal thickness in myopes and emmetropes.

MATERIALS AND METHODS

Myopic and emmetropic subjects were chosen from Kulliyyah of Allied Health Sciences, International Islamic University Malaysia (IIUM), Kuantan campus using a simple random sampling technique. The work was carried out in IIUM Optometry Clinic, IIUM Kuantan. The selected subjects were examined, and measurement was taken at the IIUM Optometry Clinic.

The inclusion criteria of the sample were based on the age range of 19 to 24 years, best spectacle-corrected visual acuity (BSCVA) of 6/6 or better and N6, and intraocular pressure (IOP) no greater than 21 mmHg. Subjects that were being selected were free from any ocular disease or surgery. The age of subjects is range from 19 to 24 years regardless of gender. Only Malaysian Malays were selected for the study. The onset of myopia is before the age of 16 years to ensure the myopia was axial in nature, i.e., the so-called juvenile-onset myopia (Chua et al., 2018; Kaiti et al., 2021; Williams & Hammond, 2019; Zadnik & Mutti, 2019). Exclusion criteria were: subjects with a history of intraocular or refractive surgery, retinal disease, glaucoma and other neurological diseases, anisometropia more than 0.50 D. Subjects who are undergoing treatment that could change the IOP and retinal thickness, eyes with abnormal OCT findings, OCT scan achieved with image quality less than eight and decentred image.

The study was carried out from March 2022 to June 2023. This research was approved by the Research and Ethics Committee for Medical Research (KAHS 74/22), IIUM and complied with the tenets of the Declaration of Helsinki. Informed consent was obtained from each subject before enrolment.

All subjects underwent evaluation of focimeter, autorefractor, distance visual acuity (VA), subjective refraction, slit-lamp examination, tonometry, and swept-source optical coherence tomography (SS-OCT). During clinical refraction, subjective refraction was performed and recorded as spherical equivalent refraction (SER). The SER is calculated by adding the sum of the sphere power with half of the cylinder power. Then, the subjects are classified as emmetropia (SER between +0.50 D and -0.50 D), low myopia (SER from -0.75 D to -2.00 D), moderate myopia (SER from -2.25 D to -5.00 D) or high myopia (SER greater than -5.00 D) (Williams & Hammond, 2019). Detailed information on OCT imaging is described in the S-S OCT manual. Data are presented in figures and false-colour topographic maps. The computer software analyses the image automatically.

In the study, the retinal structures were imaged using a commercial swept-source Topcon DRI-OCT Triton (Topcon Corporation, Tokyo, Japan). To create B and C-scan high resolution fundus images, this technology scans a narrow beam onto the retina with a central wavelength of 1 050 nm. The use of this near-infrared wavelength allows for a deeper penetration into retinal tissues, including the choroid and a portion of the sclera. On each eye, five B-scans centred on the fovea were obtained. The distance between adjacent scans was 0.15 mm. Each B-scan image was adjusted to 9 mm in length. A pixel in the image along the horizontal (vertical) direction corresponds to 8.79 m (2.02 m) in distance, according to the technical specifications. The retinal pigment epithelium (RPE) was chosen as the reference layer in this study. The technology automatically detects the RPE layer of each A-scan as the brightest signal in each B-scan. Once the RPE for each A-scan was determined, it was moved vertically to match the RPE across neighbouring columns in the B-scan. The RPE appeared as a "horizontal line" in this version of the OCT fundus image, while the rest of the morphological structures and layers maintained their size and relative position.

The CT was obtained from manual segmentation of fundus images from OCT B-scans. CT was measured from the RPE (outer border of the hyper-reflective line) to the inner sclera border. Measurement was taken on four locations which are central fovea (0 µm), 2250 µm nasal to the fovea (location N), 2250 µm (location T1) and 3375 µm (location T2) temporal to the fovea (Othman et al., 2012; Sezer et al., 2016; Fernández et al., 2022).

The retinal-macula thickness map was created by interpolating retinal thickness profiles from the six cross-sectional images using a colour scale. The Topcon Advanced Boundary Software (TABSTM) automatically analysed all scanning data and measured the thickness of the retina from the junction of the inner and outer segments of the photoreceptors to the inner limiting membrane. The macula was automatically divided into three concentric rings: the centre, inner, and outside rings, each measuring 1.0, 3.0, and 6.0 mm in diameter, as shown in Figure 1. The apparatus was centred on the foveal pit. The foveal, inner (parafovea), and outer (perifovea) macular regions were represented by the centre, inner, and outer rings, respectively. The Fast Macular Thickness OCT for emmetrope and myope are shown in Figure 2 and Figure 3, respectively.

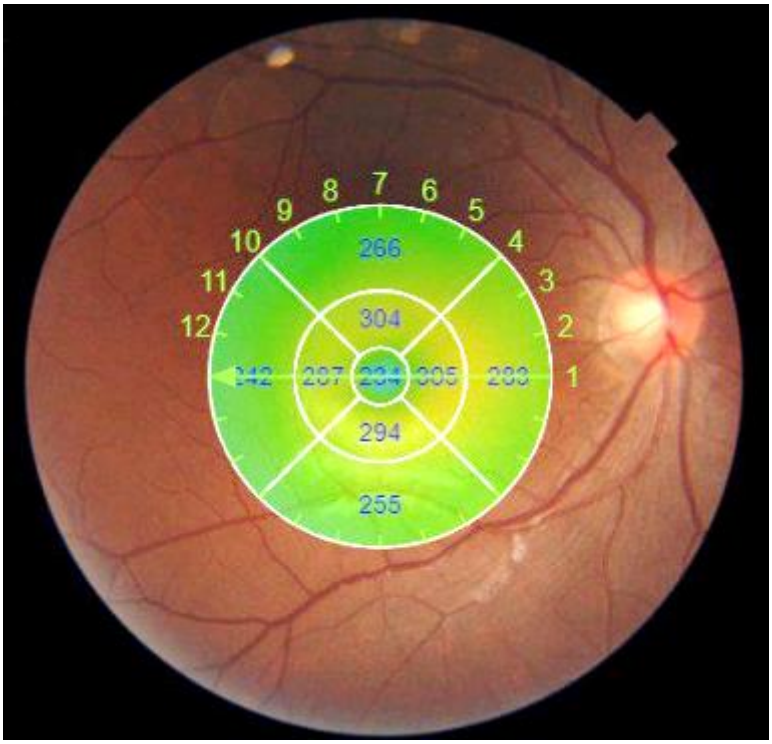

Figure 1. The Early Treatment Diabetic Retinopathy Study (ETDRS) grid of the OCT. The parafoveal region and the perifoveal region were further subdivided into superior, inferior, temporal, and nasal subfields, which consists of the OCT scanning image with resulting macular thickness and three concentric circles are formed 1.0, 3.0 and 6.0 mm in diameter around the central point of the fovea.

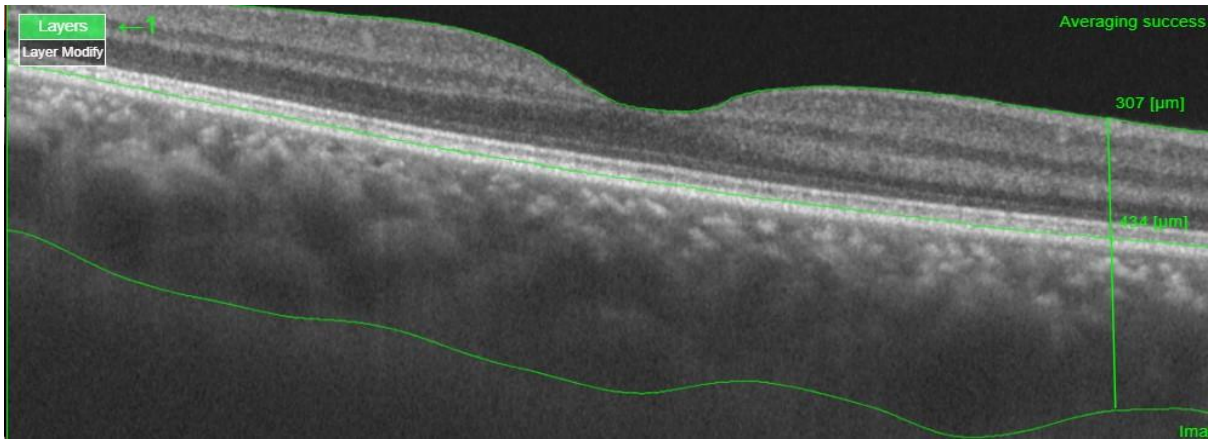

Figure 2. Fast macular thickness OCT scan from an emmetrope. Retinal thickness is measured anteriorly, from the inner limiting membrane (ILM) to the junction of the photoreceptor inner and outer segments (IS/OS) posteriorly. Meanwhile, choroidal thickness is measured from IS/OS to the junction of inner-scleral border.

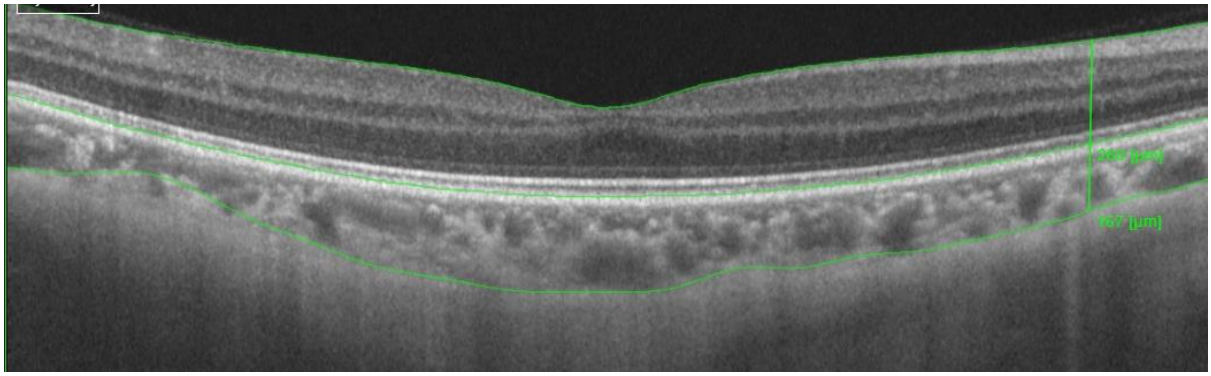

Figure 3. Fast macular thickness OCT scan from a myope. Retinal thickness is measured anteriorly, from the inner limiting membrane (ILM) to the junction of the photoreceptor inner and outer segments (IS/OS) posteriorly. Meanwhile, choroidal thickness is measured from IS/OS to the junction of inner-scleral border.

All data were analysed using the statistical package IBM SPSS version 22.0 for Windows (IBM SPSS, Armonk, NY, USA). A p-value of less than 0.05 was considered statistically significant.

RESULTS

Eighty-four (84) subjects in total were collected for measurement. However, only 46 subjects were chosen for statistical analysis. Thirty-eight (38) subjects were excluded because having the history of intraocular or refractive surgery, retinal disease, glaucoma, and other neurological diseases, anisometropia greater than 0.50 D, abnormal OCT findings, and astigmatism greater than 1.00 D.

The normal distribution of the data was analysed using the Shapiro-Wilk test of normality, skewness value and coefficient of variation (CV). As all the data were normally distributed, the one-way ANOVA test was used to compare the retinal and choroidal thickness between emmetropic and myopic Malay subjects. From the 46 eyes of the subjects enrolled in the study, there were 25 subjects categorised as emmetropia (SER -0.10 ± 0.25 D), 12 subjects were in the low myopia category (SER -1.69 ± 0.60 D), 6 subjects were moderate myopia group (SER -3.92 ± 0.86 D), and 3 subjects in the high myopia group (SER -6.17 ± 0.63 D). Foveal and regional retinal thickness measurements in each group are summarised in Table 1. There were no significant inter-group differences in the foveal thickness and in the thickness of all inner and outer rings of the macula ($p > 0.05$).

Table 1. Mean and standard deviation and one-way ANOVA results of retinal thickness in emmetropic and myopic groups

OCT Measurement	Emmetrope (n = 25)	Low Myope (n = 12)	Moderate Myope (n = 6)	High Myope (n = 3)	*p*-value
		Retinal Thickness (µm)			
Fovea	193.23 ± 38.24	208.17 ± 47.50	196.83 ± 21.76	205.33 ± 24.67	0.73
Inner Nasal	274.08 ± 27.84	285.92 ± 26.95	281.33 ± 6.06	290.67 ± 5.77	0.47
Outer Nasal	288.00 ± 23.97	282.50 ± 40.82	291.83 ± 23.20	277.67 ± 17.93	0.85
Inner Temporal	273.12 ± 23.30	282.00 ± 30.00	282.67 ± 16.51	245.33 ± 33.29	0.14
Outer Temporal	261.58 ± 20.09	249.25 ± 27.42	247.50 ± 20.67	252.00 ± 4.36	0.29
Inner Inferior	268.19 ± 39.12	278.08 ± 42.94	290.00 ± 9.70	284.33 ± 24.11	0.56
Outer Inferior	274.12 ± 20.84	273.08 ± 24.50	264.67 ± 4.84	261.67 ± 4.04	0.60
Inner Superior	290.35 ± 34.24	297.08 ± 33.84	300.00 ± 22.13	301.00 ± 5.20	0.85
Outer Superior	286.54 ± 24.86	285.08 ± 28.93	269.00 ± 23.61	267.00 ± 4.36	0.32

Whereas foveal and regional CT measurements in each group is summarised in Table 2. There were no significant inter-group differences in the foveal thickness and in the thickness of all the inner rings of the macula ($p > 0.05$). However, there were significant differences in the mean outer CT between the

myopic groups and the emmetropes at the nasal quadrant ($F(3,43 = 6.15, p < 0.05$) and the inferior quadrant ($F(3,43) = 3.84, p < 0.05$). The Dunnet post-hoc test revealed that the outer CT in the nasal area was thinner in the low, moderate, and high myopia groups than the emmetropic group. In addition, compared to the emmetropic groups, the low and moderate myopia group had a reduced outer CT at the inferior region.

Table 2. Mean and standard deviation and one-way ANOVA results of CT in emmetropic and myopic groups

OCT Measurement	Emmetrope (n = 25)	Low Myope (n = 12)	Moderate Myope (n = 6)	High Myope (n = 3)	*p*-value
		CT (µm)			
Fovea	326.25 ± 112.40	312.75 ± 75.46	257.83 ± 63.04	284.67 ± 11.68	0.45
Inner Nasal	315.19 ± 88.10	303.83 ± 75.41	248.33 ± 45.89	259.00 ± 39.05	0.24
Outer Nasal	298.92 ± 69.71	240.08 ± 48.89	214.83 ± 77.90	175.33 ± 12.58	<0.01
Inner Temporal	328.92 ± 98.23	319.92 ± 66.31	267.17 ± 76.96	283.33 ± 34.30	0.41
Outer Temporal	319.27 ± 86.95	273.17 ± 53.17	284.33 ± 29.53	308.67 ± 23.29	0.30
Inner Inferior	338.77 ± 69.68	292.17 ± 62.70	274.83 ± 55.46	276.67 ± 50.36	0.06
Outer Inferior	328.69 ± 77.72	267.83 ± 56.79	243.17 ± 32.46	288.00 ± 65.83	0.02
Inner Superior	312.69 ± 81.77	293.25 ± 63.67	304.67 ± 51.96	290.67 ± 51.32	0.87
Outer Superior	326.62 ± 78.15	320.17 ± 68.35	290.67 ± 39.17	303.67 ± 43.82	0.71

DISCUSSION

This study evaluated the variations in CT and retinal thickness in emmetropic and myopic Malay subjects. Our findings revealed that there is no influence on retinal thickness with increasing refractive error, with the exception of the CT, which decreased, notably in the outer nasal and inferior regions, with increasing refractive error.

Aydemir et al. (2021) found that myopia patients had thinner CT, retinal nerve fibre layer (RNFL), and macular layers than emmetropic and hyperopic patients. However, there were no appreciable differences in the average thickness of the retinal layer between the groups. This is also supported by a previous study done in 2020 by Heirani et al. that examined CT and refractive status and found that those with myopia had reduced CTs while people with hyperopia had greater CTs. This is also consistent with the study by Jin et al. from 2016, which found that the choroidal thickness was more significant in hyperopes and thinned in most regions in myopes. In addition, a study by Fernández et al., 2022 revealed that other works have reported minimal link between foveal thickness and axial length or refraction, not only in young eyes but even when middle-aged individuals' children and throughout a wide age range are involved. The same studies have shown that moderate to high myopia patients have thicker fovea than do non-myopic patients.

According to a study by Lee et al. (2021), the OCT type was the primary contributor of heterogeneity. It is hypothesised that CT values in healthy youngsters varied significantly between devices and were between 5.9 and 49.3 µm thinner on SS-OCT than on spectral domain OCT (SD-OCT). To our knowledge, our study is the first cross-sectional evaluation of the fundus performed on Malay patients utilising the SS-OCT. The OCT is well known as a viable method for capturing changes in the macular structure and gives the potential to image cross-sections of the retinal tissue in vivo. In our sample of emmetropic and myopic participants with a refractive error ranging from pl to -6.25 D, we used this "virtual" histology approach on living retinal tissue and discovered thinning of the choroid at the outer macula region (in two quadrants: nasal and inferior).

Our results show that there were no differences in the thickness of the fovea, inner (parafovea) and outer (perifovea) choroidal and retinal area between the emmetropic and myopic groups with the exception for outer CT at the nasal and inferior regions between emmetropic and myopic groups. This

is in agreement with a prior study by Lee et al., 2022, which found that choroidal thinning was more pronounced in the nasal and inferior areas with longer axial lengths.

Changes in CT may occur from the maintenance of vision clarity, according to the findings of several animal research. Because the image plane in myopic defocus is in front of the retina, a thickness of the choroid may push the retina in front of the image plane. Data from previous studies have demonstrated that, as part of this adjustment, CT prevents the entry of a variety of growth factors that serve as mechanical barriers and slows the growth of sclera (Lee et al., 2017). As a result, findings from both studies are congruent with findings from this study, which demonstrate that refractive error causes choroidal thinning in myopia in order to retain clear vision. This is compatible with the study's hypothesis that, in response to optical defocus, CT controls eye growth. They hypothesised that while CT can alter more easily than the eye can enlarge, repeated experiences of temporary choroidal thinning brought on by brief periods of hyperopic defocus, which is a suggested mechanism of myopigenesis, may cause ocular elongation by a mechanical or molecular mechanism (Nickla & Wallman, 2010). Thicker choroids represent a stronger physical barrier to chemical signals and growth factors travelling from the retina to the sclera, according to one of the explanations put up by the authors explaining this impact (Lee et al., 2022).

CONCLUSION

The findings of the current study, demonstrate that the outer CT at nasal and inferior areas reduces with increasing myopia. This thinned portion of the outer macula may be the initial structural alteration before any modifications to VA or other central visual functions.

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