· Clinical Research ·

Choroidal thickness measurements in young Saudi adult population: a cross-sectional study

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Abstract

● **AIM:** To determine the choroidal thickness (CT) in young healthy Saudi adults using spectral-domain optical coherence tomography (SD-OCT) with an automated CT segmentation software.

● **METHODS:** Fifty-eight young adults (total of 116 eyes), 39 males and 19 females participated in this study between the ages of 18 and 38y (mean 22.65±3.9y). All participants underwent ophthalmic screening examination, including the SD-OCT for measurements of CT in each quadrant egmented into five eccentric regions starting from the foveal region up to 4.5 mm towards the periphery.

● **RESULTS:** The choroid was thickest in the foveal region (central 1 mm, 300±60 μm) and began to progressively thinner beyond the parafovea (1.5–2.5 mm, 284±67 μm) towards the peripheral region (3.5–4.5 mm from the fovea, 254±83 μm). The superior choroid showed the thickest profile (309±57 μm), while the nasal choroid exhibited the thinnest (229±76 μm). The rate of the thinning with increasing eccentricity was more predominant in the nasal choroid, which thinned from the foveal region (294±58 μm) to the peripheral region (158±55 μm). The superior and inferior choroid did not show a statistically significant thinning with eccentricity (all P>0.05). There was no statistically significant difference in the CT between gender, age, and laterality of the eyes (all P>0.05). A significant association of myopia with thinner subfoveal choroid was observed (Pearson's, r=0.37), and regression analysis showed that a 10.3 μm choroidal thinning for each diopter increase of myopia.

● **CONCLUSION:** CT profile depends on eccentric and the quadrant. The CT profile across the measured area in the young Saudi adult population is comparable to other previous reports. Refractive error is critical for CT evaluation.

● **KEYWORDS:** choroidal thickness; optical coherence tomography; young adults; Saudi population

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INTRODUCTION

The choroid is the posterior part of the uvea that lies between the retina and sclera. It primarily consists of blood vessels that supply the outer retina. The choroid has several other essential functions, including light absorption, thermoregulation, and the modulation of intraocular pressure[1]. Several ocular conditions have been reported to be associated with changes in choroidal thickness (CT), which indicates the significant role of CT in the pathophysiology of ocular diseases that affects the retina. Choroidal thinning was reported to be associated in patients with pathological myopia[2-3], age-related macular degeneration[4], diabetic retinopathy[5-7], and glaucoma[8]. On the other hand, choroidal thickening was observed in ocular conditions such as chronic central serous chorioioretinopathy[9-10], and Vogt-Koyanagi-Harada disease[11]. More current evidence suggests that the choroid act as a regulator for axial ocular growth through communicating information from the retina to the sclera[12-13].

The recent technological advances in ocular imaging, specifically in optical coherence tomography (OCT), allowed an *in vivo* non-invasive CT measurement to be applicable. A large number of studies explored the morphology and distribution of CT in different population-based and in a variety of ocular diseases[3-20]. The CT varies significantly based on the fundus quadrant and eccentric location (fovea versus periphery)[14-15]. Typically, the choroid is thickest in the subfoveal regions and progressively thins in the peripheral regions. Quadrant wise, the superior choroid normally is the thickest, whereas the nasal choroid is the thinnest[14-15].

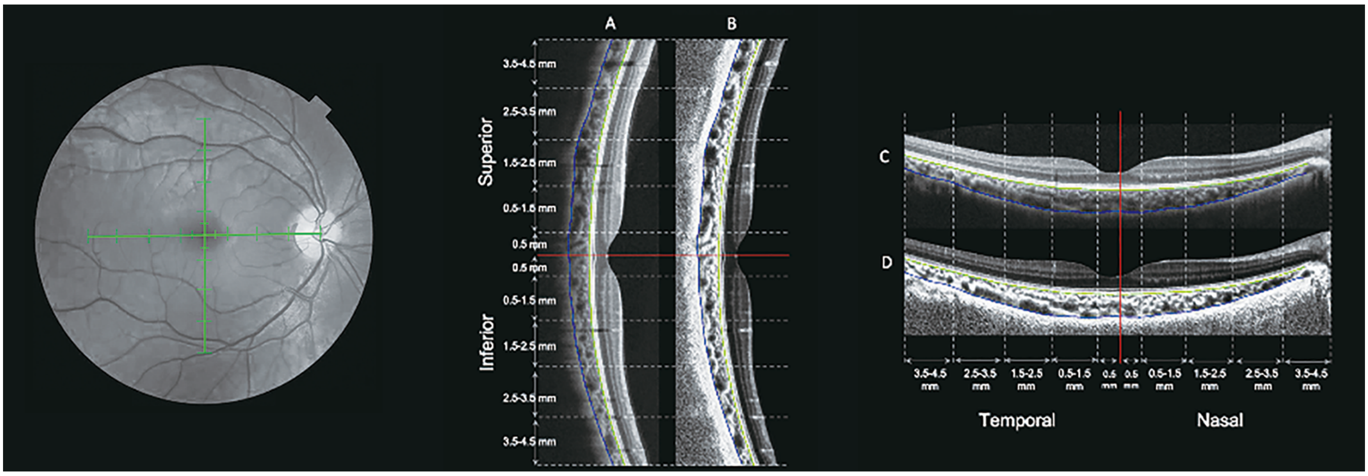

Figure 1 A representative fundus photo showing the location of the cross-section optical coherence tomography single line scans that are centered on fovea (green lines) The corresponding scans single line vertical [original vertical (A) and enhanced contrast vertical (B)], and the horizontal scans [original horizontal (C) and enhanced contrast horizontal (D)]. The red lines indicate the location of the foveal pit. The green and blue lines indicate the anterior and posterior boundaries of the choroid, respectively.

Retinal thickness measurements have become essential in the diagnosis, follow-up, and monitoring response to treatment of a variety of ocular conditions. In recent years, CT measurements have also become a subject of interest. CT is significantly influenced by several factors, such as ethnicity, refractive error, and age[16]. Many population-based studies investigated the normal range of CT. According to these studies, the range of subfoveal CT in healthy adults was reported to be from 242 to 370 μm[17-26].

There are no published reports on normal CT across a wide fundus area in the young adult Saudi population. Therefore, the aim of this study is to determine the CT regional variations in healthy young adult Saudi individuals.

SUBJECTS AND METHODS

Ethical Approval Ethics clearance was obtained from the research Ethics Board at King Saud University. All the procedures conducted in this study were in compliance with the tenets of the Declaration of Helsinki. Informed consent was obtained from each participant before data acquisition.

Participants In this cross-sectional study, 77 individuals participated. Our sample consisted of healthy younger adults who did not suffer any visual impairment. Nineteen participants were excluded due to low image quality that hindered accurate evaluation of their CT. The participants were screened before they were enrolled in the study. All the participants were residents of Riyadh City, Saudi Arabia.

Preliminary data were collected, and this includes general and ocular health history, medication, smoking habits, and caffeine intake. Individuals who suffered from any ocular disease, smokers, and pregnant women were excluded.

Procedure CT was evaluated using the Topcon Maestro 3-D spectral-domain OCT (Topcon.com). The scanning speed of the OCT was 50 000 A-scans per second. The transverse and axial resolutions were 20 and 6 μm, respectively. Three horizontal and three vertical consecutive 9-mm high-resolution single line scans were collected from each eye in the same location. All OCT scans were centred on the fovea. All OCT scans were taken under nonmydriatic conditions. Due to the reported regional variations in CT[14-15,27], CT was evaluated in five eccentric locations (*i.e.*, fovea, parafovea, perifovea, near-periphery, and peripheral region) and in all four quadrants (superior, temporal, inferior and nasal) 4.5 mm from the foveal pit (Figure 1).

Only OCT scans with a minimum of 30 averaged b-scans were analyzed. The CT was determined as the linear measurement of depth between the hyper-reflective line of the retinal pigment epithelium (RPE) to the inner scleral border. A quantification software developed by Alonso-Caneiro *et al*[28] and Read *et al*[29] was used to determine the CT. An incorporated image contrast enhancement feature was used to improve the visualization of the choroidoscleral junction line (Figure 1B, 1D)[30]. All OCT scans were analyzed by three experienced clinicians. The measurements by the three independent raters were significantly identical; the intraclass correlation coefficients (ICC) were obtained using a two-way mixed-effects model for measurements of the absolute agreement. The ICC and 95% confidence intervals (CI) were 0.98 (0.97–0.99) between the three raters.

The automated software provides 185 thickness data points per 1-mm in lateral width (*i.e.*, a total of 1760 data points from each OCT scan). Following the OCT scans segmentation, we used each participant's axial length to correct the transverse scaling to account for ocular magnification using a method previously described by Read *et al*[31]. According to the predefined eccentricities, the thickness data points were averaged to obtain the thickness value of each region.

Table 1 Demographic and ocular characteristics of participants' right eyes mean±SD (min, max)

Parameters	All subjects	Male	Female	*P* (M *vs* F)
Number (%)	58 (100)	39 (67)	19 (33)	-
Age (y)	22.65±3.9 (19, 38)	23.4±3.9 (20, 38)	23.1±3.7 (19, 36)	0.78
Spherical equivalent refractive error (D)	-1.11±1.9 (-8.62, 1.25)	-1.19±2.1 (-8.6, 1.25)	-0.98±1.1 (-4.75, 1.0)	0.22
Axial length (mm)	24.05±0.97 (21.6, 27.6)	24.1±1.0 (22.0, 27.6)	23.9±0.94 (21.5, 25.8)	0.41
Best-corrected distance visual acuity (logMAR)	-0.06±0.08 (-0.1, +0.02)	-0.07±0.08 (-0.1, +0.02)	-0.06±0.06 (-0.1, +0.02)	0.79
Average corneal curvature (D)	42.71±1.25 (40.42, 46.42)	42.69±1.22 (40.42, 45.61)	42.77±1.34 (40.91, 46.42)	0.39

The measurements of axial length were obtained by the noncontact partial coherence laser interferometry (IOL-Master) (Zeiss.com). The axial length was defined as the distance from the anterior corneal surface to the RPE. Ten repeated measurements of the axial length were gathered, and five readings with a signal-to-noise ratio greater than seven were selected and averaged for data analysis. The auto-refractometer KR-8800 (Topcon.com) was used to obtain the non-cycloplegic refraction data.

Statistical Analysis The data normality was checked using Kolmogorov-Smirnov normality test. Analysis of variance and paired *t*-tests were used to compare the regional variation in the CT, including the within-subject factors of laterality (2 levels), choroidal eccentricity (5 levels) and quadrant (4 levels). Bonferroni correction for multiple comparisons was applied when appropriate. Pearson correlation was used to study the relationship between refractive error and the CT. A *P*-value of <0.05 was considered statistically significant. All Statistical analysis was performed using SPSS version 28 (SPSS Institute Inc, Chicago, Illinois, USA). All data are expressed as mean and standard deviations.

RESULTS

Data from 116 eyes (58 participants; 39 males and 19 females) were used in the analysis. The mean age was 22.65±3.9y, and the mean refractive error was -1.6±2.06 D. Demographics and ocular characteristics of participants are listed in Table 1.

The overall CT in the entire sample was 280±72 μm. The results showed no significant difference between the right and left eyes in CT (right eyes; 279±73 μm and left eyes; 277±72 μm, *P*=0.16) and between male and female participants (male; 271±71 μm and female; 277±77 μm, *P*=0.37). The distribution of CT varied significantly with fundus quadrant and eccentricity (both *P*<0.001). The mean of subfoveal CT of the right eyes (central 1 mm region) was 298±63 μm, parafoveal (0.5–1.5 mm, 295±65 μm), perifoveal (1.5–2.5 mm, 284±70 μm), near-periphery (2.5–3.5 mm, 267±77 μm), and periphery (3.5–4.5 mm, 254±86 μm). The progressive thinning towards the periphery was observed only beyond the perifovea. The CT was significantly different in all quadrants (all *P*<0.01 for all pairwise comparisons). The superior (303±62 μm) and nasal choroid (233±79 μm) exhibited the thickest and thinnest choroid profile, respectively. The overall inferior and temporal choroid were 306±59 and 288±67 μm, respectively.

Table 2 Association between choroidal thickness in right eyes and myopia using a univariate linear mixed model

Parameters	Coefficient	SE	*P*
Fovea			
Refraction	11.2	1.9	<0.001
Intercept	310.1	4.3	<0.001
Parafovea			
Refraction	10.1	2.0	<0.001
Intercept	308.5	4.6	<0.001
Perifovea			
Refraction	10.7	2.1	<0.001
Intercept	298.5	4.8	<0.001
Near-periphery			
Refraction	10.1	2.4	<0.001
Intercept	280.4	5.2	<0.001
Periphery			
Refraction	9.1	2.5	<0.001
Intercept	266.1	6.3	<0.001

SE: Standard error.

The rate of progressive thinning in the CT differed based on quadrant (quadrant x eccentricity interaction, *P*<0.001). Significant thinning toward peripheral regions was observed in the nasal and temporal choroid in the right and left eyes. The nasal choroid of the right eyes exhibited the most thinning from the foveal (295±61 μm) to the nasal peripheral region (154±62 μm). The CT in the superior quadrant of the right eyes did not vary significantly across the measured eccentric regions (301±65 μm in the central to 296±66 μm in the periphery). Similar results were observed in the left eyes (Figures 2).

In the univariate linear mixed model, the overall CT decreased by approximately 10.3 μm for every one diopter of myopia (Table 2). No significant change in the CT was observed based on age in this study (*P*=0.1).

DISCUSSION

The choroid is a highly vascular structure that plays the role of nutrient provider to posterior ocular structures. In recent years, CT has been suggested to be a valuable biomarker in diagnosing and monitoring several retinal conditions. The main purpose of the present study was to determine the CT profile among healthy young Saudi adults. In this study, we examined the CT in 110 eyes of 58 young adult Saudi individuals.

There are three studies that explored CT in the Saudi population[32-34]. Farhan *et al*[32] included 110 young adult participants and measured the CT at three locations (subfoveal and 750 µm nasally and temporally) using OCT with confocal scanning laser ophthalmoscopy. The subfoveal CT reported by their group was comparable with what was found in our study (306±47 µm and 300±60 µm, respectively). The second study only explored the CT in healthy Saudi women, which reported the subfoveal CT to be 285±31 µm, whereas the subfoveal CT in the female participants of the current study was 308±60 µm[33]. The most recent study was conducted by Al Marshood *et al*[34]. The mean of subfoveal CT in 144 participants was 329±57 µm. All studies have relied on the average of three single data points that were obtained from three OCT scans to measure the CT in several locations. All measured CT within the central 4-mm region, and none of the studies has explored the CT in the peripheral regions and the CT profile in the superior and inferior quadrants. In the current study, a total area of the central 9.5 mm horizontally and vertically of the choroid was investigated. Additionally, the current study relied on hundreds of datapoint that was obtained from each OCT image using a semiautomated method in detecting choroidal boundaries.

The topographical variations in the CT are dependent on the quadrant and eccentricity. Several reports showed that the superior choroid is the thickest[14-15,35]. The topographical variations in CT that were observed in quadrants and eccentric locations can be explained by several factors. First, the variations in choroidal vessel size in different regions. It has been found that the CT was significantly correlated with the diameter of choroidal vasculature and the ratio of horizontal to vertical choroidal veins diameter[36-37]. Second, the asymmetry in choroidal veins distribution and location, with the superior-temporal choroid being the preferred choroidal venous drainage pathway[38]. Third, the density of choroidal microvascular and large vascular components differs depending on eccentric locations, with higher choroidal vascular density in the central fovea and lower density in the periphery[39-41].

A large number of studies reported a significant negative association between CT and the degree of myopia. The association is explained by the axial elongation and ocular stretching that myopic and highly myopic eyes experience[14]. In this study, a significant correlation between CT and refraction was found (Figure 3). The univariate regression showed there was a decrease of 10.8 µm for each diopter increase of myopia. Similar findings were reported by studies conducted on Saudis[32] and other populations[22]. In our study,

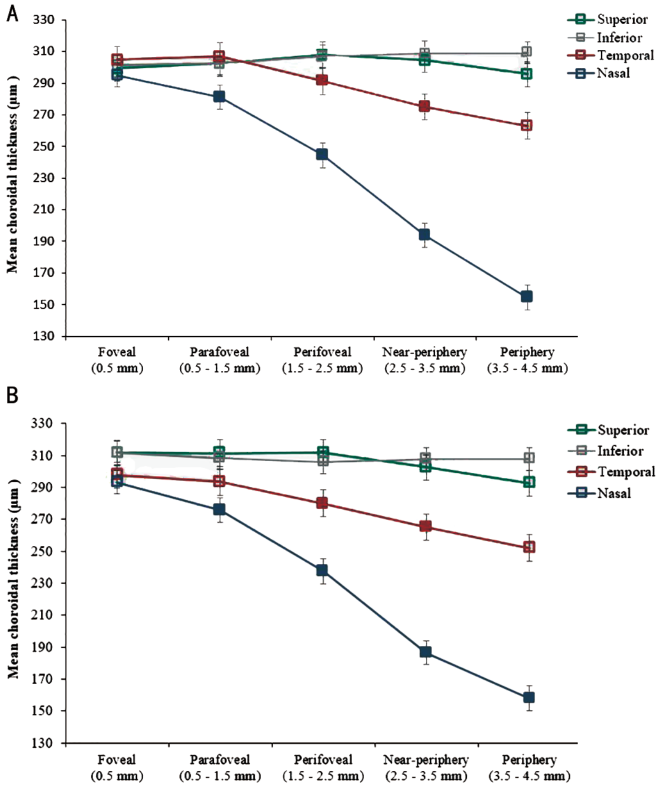

Figure 2 Mean choroidal thickness (µm) of right eyes (A) and left eyes (B) was measured in four quadrants as a function of choroidal eccentricity Error bars represent the standard error of the mean. Filled symbols represent a statistically significant difference ($P<0.05$, Bonferroni) in a given choroidal eccentricity compared to the adjacent eccentricity to the left.

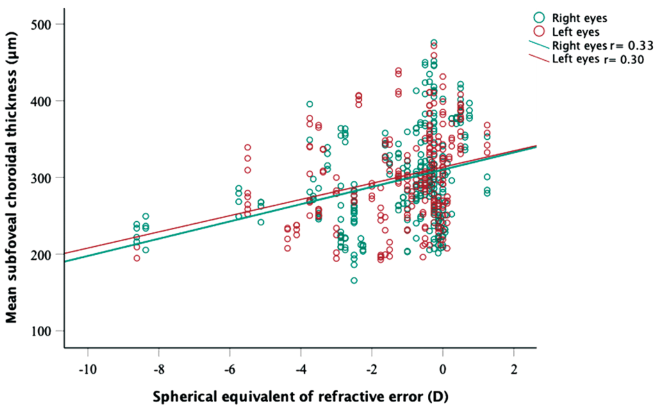

Figure 3 Scatterplot showing the correlation between subfoveal choroidal thickness and refraction.

the correlation between the refractive error and the CT varied based on eccentricity. Subfoveal CT showed to be the region to be the most significantly associated with refraction. The correlation weakened with increasing eccentricity.

In this study, no correlation was found between CT and age. Previous reports showed inconsistent associations between CT and age. Some reports found a decreased CT with increasing age[18,42-43]. A decrease of 11.9 µm in subfoveal CT for each decade increase in age was reported[44]. Those studies included participants older than 40 and up to 90 years of age. The microvascular loss occurring with age among the elderly could explain the choroidal thinning associated with age. In a younger population, a positive correlation with age was found, which indicates continuous choroidal thickening with age, and this plateaus in adolescence[31,43]. The observed lack of correlation between the CT and age in our study is likely due to the limited age range (mean±SD; 22.6±3.9, range: 19–38y) of participants in this study to detect any significant correlation. Similar findings were reported by Xie *et al*[18] where only a group of individuals over the age of 50y showed a significant negative correlation between subfoveal CT and age, where the group younger than 50y, no significant correlation was noted.

To our knowledge, this was the first study to investigate the CT morphology in the young Saudi population that explored all quadrants and up to 4.5 from the foveal region. Although, several limitations to this study need to be acknowledged. First, only horizontal and vertical single-line OCT scans were used to collect the CT data. However, volumetric imaging would offer additional information about the thickness profile and its regional variation across the choroid. Second, the study only included young adults. It is established that CT is negatively correlated with age. The generalization of the results may be limited due to the narrow age range in this study. Future studies investigating the CT in a wide range of age in the Saudi population, including older adults, are warranted. Lastly, the majority of subjects in this study were males (67%), although no significant difference between age and the baseline ocular characteristics was found. Also, the CT profile was not different between male and female participants.

In conclusion, the findings demonstrated the CT profile in healthy young Saudi adults, which showed a quadrant- and eccentricity-dependent pattern. The superior choroid exhibited to be the thickest, whereas the nasal quadrant was shown to be the thinnest. The CT progressively thinned towards the peripheral regions, and the rate of thinning was predominated in the nasal choroid. The CT was negatively correlated with refractive error.

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Conflicts of Interest: Althomali M, None; **Alharbi A,** None; **Albnayan N**, None; **Alkhudhair A,** None; **Alanazi M,** None.

REFERENCES

1 Nickla DL, Wallman J. The multifunctional choroid. *Prog Retin Eye Res* 2010;29(2):144-168.

2 Wu QY, Chen Q, Lin B, *et al*. Relationships among retinal/choroidal thickness, retinal microvascular network and visual field in high myopia. *Acta Ophthalmol* 2020;98(6):e709-e714.

3 Meng QY, Miao ZQ, Liang ST, *et al*. Choroidal thickness, myopia, and myopia control interventions in children: a Meta-analysis and systemic review. *Int J Ophthalmol* 2023;16(3):453-464.

4 Keenan TD, Klein B, Agrón E, Chew EY, Cukras CA, Wong WT. Choroidal thickness and vascularity vary with disease severity and subretinal drusenoid deposit presence in nonadvanced age-related macular degeneration. *Retina* 2020;40(4):632-642.

5 Wang W, Liu S, Qiu ZH, He M, Wang LH, Li YT, Huang WY. Choroidal thickness in diabetes and diabetic retinopathy: a swept source OCT study. *Invest Ophthalmol Vis Sci* 2020;61(4):29.

6 Torabi H, Saberi Isfeedvajani M, Ramezani M, Daryabari SH. Choroidal thickness and hemoglobin A1c levels in patients with type 2 diabetes mellitus. *J Ophthalmic Vis Res* 2019:14(3):285-290.

7 Garrido-Hermosilla AM, Méndez-Muros M, *et al*. Renal function and choroidal thickness using swept-source optical coherence tomography in diabetic patients. *Int J Ophthalmol* 2019;12(6):985-989.

8 Verticchio Vercellin A, Harris A, Stoner AM, Oddone F, Mendoza KA, Siesky B. Choroidal thickness and primary open-angle glaucoma-a narrative review. *J Clin Med* 2022;11(5):1209.

9 Liu YC, Wang Y, Chen S. Detection of macular ganglion cell complex loss and correlation with choroidal thickness in chronic and recurrent central serous chorioretinopathy. *Int J Ophthalmol* 2023;16(4):579-588.

10 Ishikura M, Muraoka Y, Nishigori N, *et al*. Widefield choroidal thickness of eyes with central serous chorioretinopathy examined by swept-source OCT. *Ophthalmol Retina* 2022;6(10):949-956.

11 Ormaechea MS, Hassan M, Mahajan S, Nguyen QD, Couto C, Schlaen A. Correlation between subfoveal choroidal thickness and anterior segment inflammation in patients with chronic stage of vogt-koyanagi-harada disease. *Ocul Immunol Inflamm* 2022;30(3):646-651.

12 Prousali E, Dastiridou A, Ziakas N, *et al*. Choroidal thickness and ocular growth in childhood. *Surv Ophthalmol* 2021;66(2):261-275.

13 Liu YL, Wang LJ, Xu YY, Pang ZX, Mu GY. The influence of the choroid on the onset and development of myopia: from perspectives of choroidal thickness and blood flow. *Acta Ophthalmol* 2021;99(7):730-738.

14 Hoseini-Yazdi H, Vincent SJ, Collins MJ, Read SA, Alonso-Caneiro D. Wide-field choroidal thickness in myopes and emmetropes. *Sci Rep* 2019;9:3474.

15 Alanazi M, Caroline P, Alshamrani A, Alanazi T, Liu M. Regional distribution of choroidal thickness and diurnal variation in choroidal thickness and axial length in young adults. *Clin Ophthalmol* 2021;15:4573-4584.

16 Bafiq R, Mathew R, Pearce E, Abdel-Hey A, Richardson M, Bailey T, Sivaprasad S. Age, sex, and ethnic variations in inner and outer retinal and choroidal thickness on spectral-domain optical coherence tomography. *Am J Ophthalmol* 2015;160(5):1034-1043.e1.

17 Mori Y, Miyake M, Hosoda Y, *et al*, Nagahama Study Group.

Distribution of choroidal thickness and choroidal vessel dilation in healthy Japanese individuals: the nagahama study. *Ophthalmol Sci* 2021;1(2):100033.

18 Xie JM, Ye LY, Chen QY, *et al*. Choroidal thickness and its association with age, axial length, and refractive error in Chinese adults. *Invest Ophthalmol Vis Sci* 2022;63(2):34.

19 Zhou H, Dai YN, Shi YY, *et al*. Age-related changes in choroidal thickness and the volume of vessels and stroma using swept-source OCT and fully automated algorithms. *Ophthalmol Retina* 2020;4(2):204-215.

20 Lee SSY, Lingham G, Alonso-Caneiro D, Chen FK, Yazar S, Hewitt AW, MacKey DA. Choroidal thickness in young adults and its association with visual acuity. *Am J Ophthalmol* 2020;214:40-51.

21 Tan CSH, Cheong KX. Macular choroidal thicknesses in healthy adults—relationship with ocular and demographic factors. *Invest Ophthalmol Vis Sci* 2014;55(10):6452.

22 Ruiz-Medrano J, Flores-Moreno I, Peña-García P, *et al*. Macular choroidal thickness profile in a healthy population measured by swept-source optical coherence tomography. *Invest Ophthalmol Vis Sci* 2014;55(6):3532-3542.

23 Gupta P, Jing T, Marziliano P, *et al*. Distribution and determinants of choroidal thickness and volume using automated segmentation software in a population-based study. *Am J Ophthalmol* 2015; 159(2):293-301.e3.

24 Wei WB, Xu L, Jonas JB, *et al*. Subfoveal choroidal thickness: the Beijing eye study. *Ophthalmology* 2013;120(1):175-180.

25 Herrera L, Perez-Navarro I, Sanchez-Cano A, *et al*. Choroidal thickness and volume in a healthy pediatric population and its relationship with age, axial length, ametropia, and sex. *Retina* 2015;35(12):2574-2583.

26 Song Y, Tham YC, Chong C, *et al*. Patterns and determinants of choroidal thickness in a multiethnic Asian population: the Singapore epidemiology of eye diseases study. *Ophthalmol Retina* 2021; 5(5):458-467.

27 Alanazi MK. Within-day changes in luminal, stromal choroidal thickness, and choroidal vascularity index in healthy adults. *Indian J Ophthalmol* 2023;71(1):166-173.

28 Alonso-Caneiro D, Read SA, Collins MJ. Automatic segmentation of choroidal thickness in optical coherence tomography. *Biomed Opt Express* 2013;4(12):2795-2812.

29 Read SA, Collins MJ, Vincent SJ, Alonso-Caneiro D. Macular retinal layer thickness in childhood. *Retina* 2015;35(6):1223-1233.

30 Girard MJA, Strouthidis NG, Ethier CR, Mari JM. Shadow removal and contrast enhancement in optical coherence tomography images of the human optic nerve head. *Invest Ophthalmol Vis Sci* 2011;52(10):7738.

31 Read SA, Collins MJ, Vincent SJ, Alonso-Caneiro D. Choroidal thickness in myopic and nonmyopic children assessed with enhanced depth imaging optical coherence tomography. *Invest Ophthalmol Vis Sci* 2013;54(12):7578.

32 Farhan HMA, Shibel LAA, Abdulmaboud M. Assessment of choroidal morphology and vasculature in healthy young Saudi adults. *Austin J Clin Ophthalmol* 2014;1(4):4.

33 Osuagwu U, Zeried F, Ngozika E, Al-Anazi M, Mashige K. Choroidal thickness measured by ocular coherence tomography (SD-OCT) and body mass index in healthy Saudi women: a cross-sectional controlled study. *Curr Med Imaging* 2022;18(6):666-673.

34 Al Marshood A, Rubio Caso MJ, AlSaedi A, Almarek F, Khandekar RB, Semidey VA. Optical coherence tomography based choroidal thickness and its determinants in healthy Saudi population: a cross-sectional study. *Cureus* 2023;15(1):e34152.

35 Yazdani N, Ehsaei A, Hoseini-Yazdi H, *et al*. Wide-field choroidal thickness and vascularity index in myopes and emmetropes. *Ophthalmic Physiol Opt* 2021;41(6):1308-1319.

36 Rasheed MA, Singh SR, Invernizzi A, Cagini C, Goud A, Sahoo NK, Cozzi M, Lupidi M, Chhablani J. Wide-field choroidal thickness profile in healthy eyes. *Sci Rep* 2018;8(1):17166.

37 Tanabe H, Ito Y, Iguchi Y, Ozawa S, Ishikawa K, Terasaki H. Correlation between cross-sectional shape of choroidal veins and choroidal thickness. *Jpn J Ophthalmol* 2011;55(6):614-619.

38 Mori K, Gehlbach PL, Yoneya S, Shimizu K. Asymmetry of choroidal venous vascular patterns in the human eye. *Ophthalmology* 2004;111(3):507-512.

39 McLeod DS, Lutty GA. High-resolution histologic analysis of the human choroidal vasculature. *Invest Ophthalmol Vis Sci* 1994;35(11):3799-3811.

40 Adhi M, Ferrara D, Mullins RF, *et al*. Characterization of choroidal layers in normal aging eyes using enface swept-source optical coherence tomography. *PLoS One* 2015;10(7):e0133080.

41 Ferrara D, Waheed NK, Duker JS. Investigating the choriocapillaris and choroidal vasculature with new optical coherence tomography technologies. *Prog Retin Eye Res* 2016;52:130-155.

42 Akhtar Z, Rishi P, Srikanth R, Rishi E, Bhende M, Raman R. Choroidal thickness in normal Indian subjects using Swept source optical coherence tomography. *PLoS One* 2018;13(5):e0197457.

43 Lee GY, Yu S, Kang HG, *et al*. Choroidal thickness variation according to refractive error measured by spectral domain-optical coherence tomography in Korean children. *Korean J Ophthalmol* 2017;31(2):151.

44 Ho M, Liu DT, Chan VC, Lam DS. Choroidal thickness measurement in myopic eyes by enhanced depth optical coherence tomography. *Ophthalmology* 2013;120(9):1909-1914.