Choroidal Thickness in Turkish Population

Türk Toplumunda Koroidal Kalınlık

Raşit KILIÇ[1], Ali KURT[1]

ABSTRACT

Aim: Our aim was to evaluate choroidal thickness in healthy Turkish subjects with enhanced depth imaging optical coherence tomography.

Materials and Methods: In this study, a total of 171 healthy subjects consisting of 87 females and 84 males were evaluated. The right eye was assessed in all participants. Seven measurement points were measured horizontally at the subfovea and across the fovea at 500-µm intervals up to 1500 µm nasal and temporal to the fovea.

Results: The mean age was 39.6±11.1 (18-62). The vision acuity was perfect in all subjects. The mean subfoveal choroidal thickness was 365.6±98.1 µm. The mean intraocular pressure and spherical equivalent were 15±2.6 mmHg and -0.13±0.70 diopter respectively. There were no significant differences between females and males for choroidal thicknesses (p>0.05). There were negative correlations between age, spherical equivalent and choroidal thicknesses. Subfoveal choroidal thickness was decreased by 3.03 µm per age according to regression analysis.

Conclusion: The mean subfoveal choroidal thickness was found to be 365.6±98.1 µm in all participants. A 3.03 µm decrease was found per age.

Key words: Choroidal thickness, enhanced depth imaging, optical coherence tomography.

ÖZ

Amaç: Amacımız sağlıklı Türk bireylerde enhanced depth imaging optik koherens tomografi ile koroidal kalınlığı değerlendirmektir.

Gereç ve Yöntem: Bu çalışmada 87 kadın ve 84 erkek olmak üzere toplam 171 olgu değerlendirildi. Tüm katılımcıların sağ gözleri değerlendirildi. Foveada ve nazal ve temporalde horizontal olarak foveadan 500 µm aralıklarla 1500 mikrometreye kadar toplam 7 noktada ölçümler yapıldı.

Bulgular: Ortalama yaş 39.6±11.1 (18-62) idi. Tüm bireylerde görme keskinliği tamdı. Ortalama subfoveal koroidal kalınlık 365.6±98.1 µm idi. Ortalama göz içi basıncı ve sferik eşdeğer sırasıyla 15±2.6 mmHg ve -0.13±0.70 diyoptiri idi. Kadın ve erkekler arasında koroidal kalınlıklar açısından anlamlı farklılıklar yoktu (p>0.05). Yaş, sferik eşdeğer ve koroidal kalınlık arasında negatif korelasyon vardı. Regresyon analizi sonucuna göre subfoveal koroidal kalınlık her yaş 3.03 µm azalmaktaydı.

Sonuç: Tüm katılımcılarda ortalama subfoveal koroidal kalınlık 365.6±98.1 µm olarak bulundu. Her yaş için 3.03 µm azalma bulundu.

Anahtar kelimeler: Enhanced depth imaging, koroidal kalınlık, optik koherens tomografi

1- Yrd. Doç. Dr., Ahi Evran Üniversitesi Tıp Fakülütesi, Göz Hastalıkları AD. Kırşehir - TÜRKİYE

Geliş Tarihi - Received: 06.09.2016
Kabul Tarihi - Accepted: 15.07.2016
Ret-Vit 2017;26:138-142

Yazışma Adresi / Correspondence Adress:
Raşit KILIÇ
Ahi Evran Üniversitesi Tıp Fakülütesi, Göz Hastalıkları AD
Kırşehir - TÜRKİYE

Phone: +90 352 437 4901
E-mail: kilicrasit@gmail.com

INTRODUCTION

The choroid is one of the tissues with the highest blood flow in the body. It is vital for the blood supply of the outer retina and retinal pigment epithelium (RPE). Photoreceptor cells in the fovea have high oxygen and metabolic exchange needs. Choroid is the only source of oxygen and metabolic exchange for the avascular fovea and it is therefore very important structure for the central vision.[1]

Optical coherence tomography (OCT) is a non-invasive method that can provide sectional images from the anterior and posterior segments of the eye. It has therefore become an important device in the routine clinical practice. The choroid can be imaged comprehensively with the recently developed technique of enhanced depth imaging optical coherence tomography (EDI-OCT).[2] It has been possible to identify the normal choroid and the changes in many systemic and ophthalmic disorders such as glaucoma, polypoidal choroidal vasculopathy, age related macular degeneration, Vogt-Koyanagi-Harada, hypertension and diabetes mellitus.[3-8]

There are many studies reporting choroidal thickness in different healthy populations from different countries.[9-12] In this study, we believed that the measurement of choroidal thickness will contribute to the understanding the physiological status in the choroid and therefore aimed to evaluate choroidal thickness in healthy subjects with EDI-OCT.

MATERIALS AND METHODS

This study protocol was conducted according to the Helsinki Declaration principles at Ahi Evran University Training And Research Hospital's Eye Clinic. A total of 171 subjects were evaluated. Written informed consent was obtained from all subjects before the enrollment. Only the right eye was evaluated in all participants.

All subjects underwent comprehensive ophthalmic examinations, including intraocular pressure measurement with the noncontact tonometer, visual acuity measurement with the Snellen chart, slit lamp biomicroscopy, dilated fundus examination, and choroidal thickness measurement with EDI-OCT (Software version 6.3.3.0, Heidelberg Engineering Inc., Heidelberg, Germany). Exclusion criteria included visual acuity less than 0.8, a spherical equivalent refractive error of more than +2 or -2 diopters, with a history of any ocular pathology, ocular surgery or trauma, any systemic disease such as diabetes mellitus, hypertension and Behçet's disease, pregnancy and those using any ocular or systemic medication.

The choroidal imaging was taken as a single horizontal line scan, passing through the center of the fovea, using the previously described method of the EDI-OCT. The OCT device contained a superluminescent diode with a wavelength of 870 nm and was capable of providing 40.000 A-scans per second. The axial resolution was 7 µm and the transverse resolution was 14 µm. Two high-quality horizontal line scans were obtained passing through the fovea using a 1x30-degree area, in which 100 scans were averaged for each section. We defined the choroidal thickness as the distance between the outer reflective RPE layer and the inner sclera border. Seven measurement points were measured horizontally at the subfovea and across the fovea at 500-µm intervals up to 1500 µm nasal and temporal to the fovea. The choroidal thicknesses were performed manually by the same ophthalmologist (RK) in all participants (Figure 1).

The SPSS 22.0 (Chicago, IL, USA) software was used for data analysis. The Kolmogorov-Smirnov test was used to evaluate consistency of the data with a normal distribution. Paired t-test, Pearson correlation test and regression analysis were used as statistical methods. P values smaller than 0.05 were considered as statistically significant.

RESULTS

In this study, a total of 171 healthy subjects consisting of 87 females and 84 males were evaluated. The mean age was 39.6±11.1 (18-62) in all subjects and 39.8±10.9 (19-61) in females, 39.3±11.3 (18-62) in males. The vision acuity was perfect in all subjects. The mean subfoveal choroidal thickness was 365.6±98.1 µm in all participants (Table 1). The

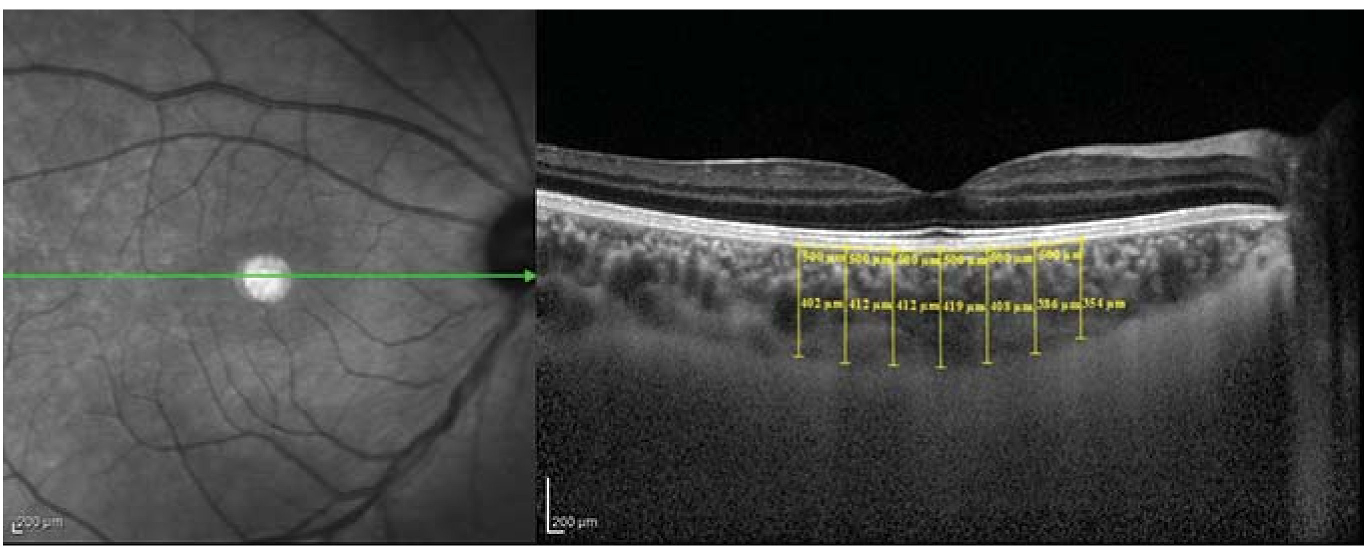


Figure 1:

Tablo 1: *Choroidal thicknesses in females, males and total subjects*			
	Females (n=87)	Males (n=84)	Total (n=171)
CT_{n1500}	307.5±95.9	293.1±82.6	300.6±89.6
CT_{n1000}	335±98.3	322.3±82.9	328.8±91.1
CT_{n500}	358±100.1	345.7±84.1	352±92.5
Subfoveal CT	367.8±103.8	363.4±92.4	365.6±98.1
CT_{t500}	366.3±95.6	352.7±91.7	359.6±93.7
CT_{t1000}	356.3±93.8	345.3±90.4	350.9±92.1
CT_{t1500}	348.8±92.6	336.5±88.1	340.2±90.2

CT_{n1500}, choroidal thickness at 1500 µ nasal to the fovea; CT_{n1000}, choroidal thickness at 1000 µ nasal to the fovea; CT_{n500}, choroidal thickness at 500 µ nasal to the fovea; Subfoveal CT, choroidal thickness at the fovea; CT_{t500}, choroidal thickness at 500 µ temporal to the fovea; CT_{t1000}, choroidal thickness at 1000 µ temporal to the fovea; CT_{t1500}, choroidal thickness at 1500 µ temporal to the fovea.

mean intraocular pressure and spherical equivalent were 15±2.6 mmHg and -0.13±0.70 diopter respectively. There was no difference between females and males for age, intraocular pressure and spherical equivalent (p>0.05). When we compared the choroidal thicknesses between males and females, no statistically significant difference was found (p>0.05). There was a negative correlation between age, spherical equivalent and choroidal thicknesses (Table 2). Choroidal thickness was reduced by age and subfoveal choroidal thickness was decreased by 3.03 µm per age according to regression analysis (Graphic 1 and table 3).

DISCUSSION

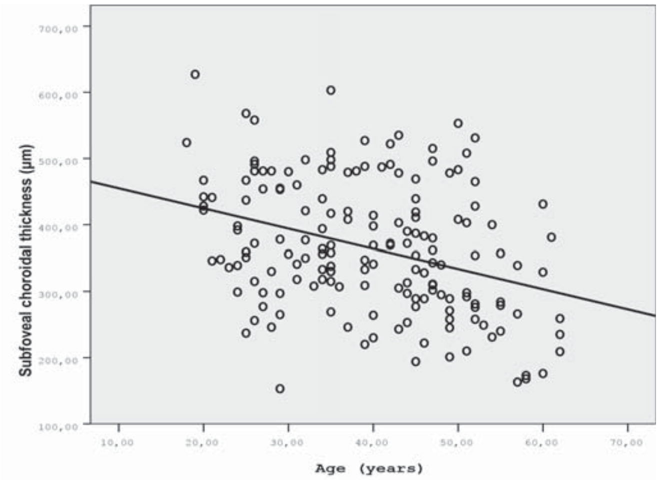
The choroid has a common vascular meshwork and carries oxygen and metabolites to the outer retinal layers and RPE. The changes of the choroidal blood flow can unfavorably affect the fovea and visual acuity (1). A lot of diseases such as age-related macular degeneration, polypoidal choroidal vasculopathy, angioid streaks, central serous chorioretinopathy and degenerative miyopia originate from the choroid (4,5,13-15). On the other hand, certain inflammatory disorders involving the posterior segment of the eye such as Vogt-Koyanagi-Harada, Behçet's disease and sarcoidosis seem to target the choroid (16-18). Besides, many systemic disorders can influence on choroidal structure by affecting hemodynamics (7,8). Thus, the relationship between choroidal thickness and systemic and ophthalmic diseases was investigated in many studies (3-8,13,14,16-18). Diabetes

Tablo 2: *Correlation between the age, spherical equivalent and choroidal thickness.*							
	CT_{n1500}	CT_{n1000}	CT_{n500}	Subfoveal CT	CT_{t500}	CT_{t1000}	CT_{t1500}
Age	r=-0.265 p=0.001	r=-0.270 p=0.001	r=-0.292 p=0.001	r=-0.342 p=0.001	r=-0.384 p=0.001	r=-0.401 p=0.001	r=-0.377 p=0.001
Sferical equivalent	r=-1.41 p=0.070	r=-0.137 p=0.079	r=-0.177 p=0.023	r=-0.174 p=0.026	r=-1.90 p=0.015	r=-0.222 p=0.004	r=-0.195 p=0.012

CT_{n1500}, choroidal thickness at 1500 µ nasal to the fovea; CT_{n1000}, choroidal thickness at 1000 µ nasal to the fovea; CT_{n500}, choroidal thickness at 500 µ nasal to the fovea; Subfoveal CT, choroidal thickness at the fovea; CT_{t500}, choroidal thickness at 500 µ temporal to the fovea; CT_{t1000}, choroidal thickness at 1000 µ temporal to the fovea; CT_{t1500}, choroidal thickness at 1500 µ temporal to the fovea.

Table 3: *Subjects were grouped according to age with choroidal thickness.*							
Age groups	CT_{n1500}	CT_{n1000}	CT_{n500}	**Subfoveal CT**	CT_{t500}	CT_{t1000}	CT_{t1500}
18-29 (n=42)	314.4±78.9	344.7±85	370.9±92.5	**394.5±100.1**	391.2±100	388.3±94.1	376.6±94.3
30-39 (n=42)	329.2±88	354±92.7	380.9±85.5	**390.7±84.5**	388.5±78.4	377.4±86.2	364.1±89.5
40-49 (n=52)	287.2±82.2	315.9±80.3	336.4±82.5	**352.8±88**	341.5±81.6	327.9±80.2	315.9±73.4
50-62 (n=35)	269.9±103.4	298.6±102.1	317.7±102	**319.9±107.7**	314±97.4	308.3±88.3	304±87.3

CT_{n1500}, choroidal thickness at 1500 µ nasal to the fovea; CT_{n1000}, choroidal thickness at 1000 µ nasal to the fovea; CT_{n500}, choroidal thickness at 500 µ nasal to the fovea; Subfoveal CT, choroidal thickness at the fovea; CT_{t500}, choroidal thickness at 500 µ temporal to the fovea; CT_{t1000}, choroidal thickness at 1000 µ temporal to the fovea; CT_{t1500}, choroidal thickness at 1500 µ temporal to the fovea.



Graphic 1: Scatter plot of subfoveal choroidal thickness and age in all participants. The regression analysis formulation was 485.29 – 3.03 x age (p=0.001 and R^2= 0.117).

mellitus and hypertension as systemic diseases have effect on the vascular structures and have been reported to influence choroidal thickness.[7,8] While a statistically significantly thicker choroidal thickness was found in many systemic immune-mediated inflammatory disorders, no found in others.[19-22] For this reason, understanding the physiological state of choroid becomes very important when the pathological conditions are investigated in the eye. There are many studies evaluating the choroidal thickness in normal population for different ethnic groups. It was reported that choroidal thickness can change according to ethnicity in the studies. We therefore believed that the establishing of the normal data of choroidal thickness for an ethnic population is essential and carried out this study in Turkish subjects.

Choroidal thickness is similar in both eyes of each individual. We believe that is the wrong way collecting of data from both eyes to assess choroidal thickness for statistical analysis. However, most of studies were carried out using both eyes especially from Turkey. We therefore evaluated only one eye in a participant in all subjects. There were several studies evaluating choroidal thickness in healthy Turkish subjects in the literature.[23-27] Ozdogan Erkul et al. stated that the mean subfoveal choroidal thickness was 280.2±81.2 µm.[23] Coşkun et al. reported that the mean subfoveal choroidal thickness was 326±60 µm in their study. They also informed that the mean subfoveal choroidal thicknesses were 324±69 and 329±40 µm in males and females respectively and no significant difference between females and males.[24] The mean subfoveal choroidal thickness was reported to be 268.8±49.2 µm by Tuncer et al. The mean subfoveal choroidal thickness of male was greater than females (291.3±53.1 µm and 252.7±40.9 µm respectively) and this difference was found statistically significant in the study.[25] However, Gök et al. reported significantly thicker choroid in females than males.[26] We found that the mean subfoveal choroidal thicknesses were 367.8±103.8 in females, 363.4±92.4 in males and 365.6±98.1 µm in all subjects. The difference between females and males was no statistically significant. Many studies were reported subfoveal choroidal thickness in different ethnic populations from different countries.[9-12] From Japan, Ikuno et al. reported the mean subfoveal choroidal thickness to be 354 ± 111 µm.[9] Fujiwara et al. also reported that the mean subfoveal choroidal thickness was 265.5 ± 82.4.[10] The measurement values of choroidal thickness can be change in a wide range. The results of choroidal thickness measurements therefore differ from one study to an other in an ethnic population. These results demonstrate that mean subfoveal choroidal thickness needs to be verified with larger sample sizes. Another explanation can be possible that is the difficulties determining the exact choroidal border.

It is well known that there is a negative correlation between age and choroidal thickness.[9-12,23-27] In this study, we found negative correlations between choroidal thicknesses and age and spherical equivalent. Coskun et al. and Ozdogan Erkul et al. also reported a negative correlation between choroidal thickness and age in the studies from Turkey. While Coskun et al. found a negative correlation between choroidal thickness and spherical equivalent, Ozdogan Erkul et al. no found.[23,24] However, there was a negative correlation between choroidal thickness and spherical equivalent in most of studies.[14,23,27,28] We observed that subfoveal choroidal thickness was decreased by 3.03 µm per age. Coskun et al. reported 0.93 µm decrease, Gök et al. reported 1.8 µm decrease, Ozdogan Erkul et al. reported 3.14 µm decrease per age in the other studies from Turkey.[23,24,26]

In conclusion, we found that the mean subfoveal choroidal thickness was 351±99 µm in all participants. There were negative correlations between subfoveal choroidal thickness and age and spherical equivalent in this study. A 3.03 µm decrease was found per age. We believe that determining mean choroidal thickness needs to be verified with larger sample sizes.

REFERENCES / KAYNAKLAR

1. Mrejen S, Spaide RF. Optical coherence tomography: imaging of the choroid and beyond. Surv Ophthalmol 2013;58:387-429.
2. Spaide RF, Koizumi H, Pozzoni MC. Enhanced depth imaging spectral-domain optical coherence tomography. Am J Ophthalmol 2008;146:496-500.
3. Toprak I, Yaylalı V, Yildirim C. Age-based analysis of choroidal thickness and choroidal vessel diameter in primary open-angle glaucoma. Int Ophthalmol. 2016;36:171-7.
4. Chung SE, Kang SW, Lee JH, et al. Choroidal thickness in polypoidal choroidal vasculopathy and exudative age-related macular degeneration. Ophthalmology 2011;118:840–5.
5. Polat OA, Sinim N, Öner A. Choroidal thickness in dry age-related macular degeneration. Ret-Vit 2013;21:265-8.
6. Maruko I, Iida T, Sugano Y, et al. Subfoveal choroidal thickness after treatment of Vogt-Koyanagi-Harada disease. Retina. 2011;31:510-7.
7. Özçimen M, Sakarya Y, Göktaş S, ve ark. Tip 2 diyabet hastalarında spektral-domain optik koherens tomografi ile koroid kalınlığının değerlendirilmesi. MN Oftalmoloji 2014;21:262-6.
8. Akay F, Gundogan FC, Yolcu U, et al. Choroidal thickness in systemic arterial hypertension. Eur J Ophthalmol 2016;26:152-7.
9. Ikuno Y, Kawaguchi K, Nouchi T, et al. Choroidal thickness in healthy Japanese subjects. Invest Ophthalmol Vis Sci. 2010;51:2173-6.

10. Fujiwara A, Shiragami C, Shirakata Y, et al. Enhanced depth imaging spectral-domain optical coherence tomography of subfoveal choroidal thickness in normal Japanese eyes. Jpn J Ophthalmol. 2012;56:230-5.
11. Ding X, Li J, Zeng J, et al. Choroidal thickness in healthy Chinese subjects. Invest Ophthalmol Vis Sci. 2011;52:9555-60.
12. Chhablani J, Rao PS, Venkata A, et al. Choroidal thickness profile in healthy Indian subjects. Indian J Ophthalmol. 2014;62:1060-3.
13. Erol MK, Çoban DT, Toslak D, et al. Bilateral choroidal thickness of patients with unilaterally active chorioretinopathy. Ret-Vit 2015;23:321-325.
14. Fujiwara T, Imamura Y, Margolis R, et al. Enhanced depth imaging optical coherence tomography of the choroid in highly myopic eyes. Am J Ophthalmol 2010;148: 445–50.
15. Vadalà M, Pece A, Cipolla S, et al. Angioid streak-related choroidal neovascularization treated by intravitreal ranibizumab. Retina. 2010;30:903-7.
16. Egawa M, Mitamura Y, Akaiwa K, et al. Changes of choroidal structure after corticosteroid treatment in eyes with Vogt-Koyanagi-Harada disease. Br J Ophthalmol. 2016 Feb 23 [Epub ahead of print].
17. Ishikawa S, Taguchi M, Muraoka T, et al. Changes in subfoveal choroidal thickness associated with uveitis activity in patients with Behcet's disease. Br J Ophthalmol. 2014;98:1508-13.
18. Mehta H, Sim DA, Keane PA, et al. Structural changes of the choroid in sarcoid- and tuberculosis-related granulomatous uveitis. Eye (Lond). 2015;29:1060-8.
19. Tetikoglu M, Temizturk F, Sagdik HM, et al. Evaluation of the choroid, fovea, and retinal nerve fiber layer in patients with rheumatoid arthritis. Ocul Immunol Inflamm. 2015 Dec 30:1-5. [Epub ahead of print]
20. Kola M, Kalkisim A, Karkucak M, et al. Evaluation of choroidal thickness in ankylosing spondylitis using optical coherence tomography. Ocul Immunol Inflamm 2014;22:434-8.
21. Onal IK, Yuksel E, Bayrakceken K, et al. Measurement and clinical implications of choroidal thickness in patients with inflammatory bowel disease. Arq Bras Ophthalmol 2015;78:278-82.
22. Kılıç R, Kurt A, Acer E, et al. Choroidal thickness in psoriasis. Int Ophthalmol. 2016 May 11 [Epub ahead of print].
23. Ozdogan Erkul S, Kapran Z, Uyar OM. Quantitative analysis of subfoveal choroidal thickness using enhanced depth imaging optical coherence tomography in normal eyes. Int Ophthalmol. 2014;34:35-40.
24. Coşkun E, Okumuş S, Gürler B, et al. Choroidal thickness in healthy Turkish subjects. Turk J Med Sci. 2014;44:56-61.
25. Tuncer İ, Karahan E, Zengin MÖ. Subfoveal choroidal thickness in normal eyes measurement using optical coherence tomography. Ret-Vit 2014;22:137-9.
26. Gök M, Aslan MŞ, Karabaş L. Evaluation of choroidal thickness by using optical coherence tomography in healthy individuals. Ret-Vit 2014;22:184-8.
27. Tuncer I, Karahan E, Zengin MO, et al. Choroidal thickness in relation to sex, age, refractive error, and axial length in healthy Turkish subjects. Int Ophthalmol. 2015;35:403-10.
28. Ceylan E, Yılmaz YC, Özer MD, et al. Choroidal thickness measurement and relationship between choroidal thickness and axial length spherical equivalent and age in highly myopic eyes. Ret-Vit 2015;23:317-20.