Comparison Degree of Myopia with Central Fovea and Subfoveal Choroidal Thicknesses

Santral Fovea ve Subfoveal Koroid Kalınlıklarının Miyopi Derecesi ile İlişkisi

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ABSTRACT

Purpose: This study aims to investigate the relationship between central fovea and subfoveal choroidal thicknesses with increasing degree of myopia.

Methods: The study group consisted of 18 high myopia patients with 29 eyes and 24 degenerative myopia patients with 36 eyes. Axial length, central fovea and subfoveal choroidal thicknesses of the subjects were compared. The degenerative group had severe myopia with a refractive error of -6D and above. In addition, a control group of 31 emmetropic patients with 62 eyes was included in the study. The subjects received a check-up at the beginning. It included inquiry of systemic and ocular disease, Snellen chart corrected visual acuity (BCVA) and intraocular pressure measurement, an axial length measurement of the eye by Aviso Ultrasonographic and biometric devices in A mode, biomicroscopic examination, detailed fundus examination, and measurements of the central fovea and subfoveal choroidal thickness by DRI HD-OCT SS Triton device. Statistical analysis was done with SPSS 11.5 program. Paired t-test was used to evaluate the relationship among the groups.

Findings: No correlation existed between axial length and CFT, but a negative correlation between axial length and SFCT in the high and degenerative myopia groups (r = -0.459 and r = -0.051, p = 0.431).The thinnest SFCT was found in degenerative myopia group (123.97µm) and the thickest in the emmetropic subjects (291.12µm).

Result: As axial length increases, central foveal thickness remains constant, while subfoveal choroidal thickness decreases. However, increased axial length alone did not affect BCVA in high myopia subjects, while significantly reduced BCVA in the degenerative group.

Key Words: Axial length, Central foveal thickness (CFT), Subfoveal choroidal thickness (SFCT), Optical coherence tomography (OCT).

ÖZ

Amaç: Santral fovea ve subfoveal koroid kalınlıklarının artan miyopi derecesi ile ilişkinin araştırılması.

Yöntem: Çalışma grubuna 18 yüksek miyop hastanın 29 gözü ve 24 dejeneratif hastasının 36 gözü, kontrol gruba ise 31 emetrop hastanın 62 gözü dahil edildi. Tüm hastalara sistemik ve oküler hastalıklar yönünden sorgulama, Snellen eşelinde düzeltilmiş en iyi görme keskinliği ölçümü (DEİGK), göz içi basınç ölçümü, Aviso ultrasonografi ve biyometri cihazında gözün aksiyel uzunluk ölçümü (AXL), biomikroskopi ve ayrıntılı fundus muayenesi, ve en son DRI HD-OCT Triton cihazında santral fovea ve subfoveal koroid kalınlıklarının ölçümleri yapılmıştır. Verilerin istatistiksel analizi SPSS 11.5 programı ile yapıldı. Gruplar arasındaki ilişkileri değerlendirmek için eşleştirilmiş t-testi kullanıldı.

Bulgular: Çalışma sonucuna göre artan aksiyel uzunlukla SFK arasında korelasyon olmadığını; ancak yüksek ve dejeneratif miyop gruplarında aksiyel uzunlukla SKK arasında negatif korelasyon (r =-0.459, p < 0.05 and r =-0.051, p = 0.431) olduğu saptanmıştır. En ince SKK (123.97 ± 59.26 µm) dejeneratif miyop grubunda, en kalın SKK (291.12 ± 52.05 µm) emetrop (kontrol) grubunda ölçülmüştür.

Sonuç: Aksiyel uzunluk arttıkça subfoveal koroid kalınlığı azalmakta, santral fovea kalınlığı ise değişmemektedir. Bununla birlikte, aksiyel uzunluğun artışı tek başına düzeltilmiş en iyi görme keskinliğini etkilemezken, dejeneratif bulguların artışı DEİGK'i önemli düzeyde azaltmaktadır.

Anahtar Kelimeler: Aksiyel uzunluk (AXL), Santral fovea kalınlığı (SFK), Subfoveal koroid kalınlığı (SKK), Optik koherens tomografi (OKT).

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INTRODUCTION

Myopia has been becoming an ophthalmological issue as over 80 million children worldwide are currently suffering from this disease. Between 7% and 70% of people in any population are living with it. Myopia results in focusing images on light-sensitiveve tissue in the back of the eye instead of the retina (Figure 1).

People with myopia have good near vision. Myopia is caused by various factors including axial myopia, curvature myopia, index myopia, iatrogenic myopia. It could be genetic or acquired. Heredity of myopic disease is rare, and its reasons are not known. It could emerge around the ages of 2-3. On the other hand, acquired myopia starts after the age 4. It is caused by a longer axial length in the eye. They cannot see further objects in normal clarity and are usually squinting to see them.

If a person has an eye with an axial length shorter than 23.5 mm, between 25.5 mm and 32.5 mm, and over 32 mm were classified as simple, intermediate and degenerative, respectively.[4,5] Refraction error of a simple myopia patient ranges between 0,25 D and -5 D. Its fastest increase occurs between 7 and 13 years old; it peaks at 20 y.o. Simple myopia is the most common disease and comprised 90% of all myopia patients. Generally, stays constant after that. Intermediate or high myopia was discovered by Otsuka[6] in 1967. It starts early ages and increases rapidly about 1 D per year. Its level hovers between -6d and -12D until the age of 30. Last type of myopia, pathologic axial or degenerative myopia, has a continuous advancing characteristic in increasing of the axial length of the eye. It causes degenerative changes in the retina. Its advance could continue after 25 and older ages, and eventually can reach up to -15 D and 25 D or more. Visual acuity is never full despite the complete correction of the optical defect. Most of the time, patients continue their life with a legally blind vision. In order to diagnose it, the eye retina and choroidal degenerative changes such as myopic crescent, Fuchs spots, exudates, posterior staphyloma, retinal breaks, scarring, and retinal detachment.[7] Fundus images captured at our clinic is shown on figure 2.

Myopic patients have thinner retinal and central choroid thickness than others in the population; complications including foveoschisis, degenerative macular hole, and choroidal neovascular membrane are more likely to occur.[8] In order to determine such complications on time, detailed examination of retina and choroid have to be conducted by advanced devices such as OCT and fundus cameras.

Previous researches were conducted on central foveal and choroidal thicknesses.[9-20] Nishida et al. (2012)[12] conducted a study to examine predictive factors for visual acuity in highly myopic eyes. a total of 86 patients with 145 eyes diagnosed with high myopia participated in that study.

It took place at two distant retina centers in USA and in Japan. The central foveal, outer retinal hypo-reflective layer and inner segment to the retinal pigment epithelium, and the subfoveal choroidal thickness were measured by a depth imaging optical coherence tomography. Correlations between measured variables and visual acuity were calculated. They concluded that the subfoveal choroidal thickness has significantly inverse correlation with age and myopic refractive spherical equivalent. Their results also showed that the only significant predictor in the visual acuity was subfoveal choroidal thickness. Clinical location was not a significant predictor.

Manjunath and others[13] examined choroidal thickness and area in healthy eyes using a spectral-Cirrus brand domain optical coherence tomography (SD-OCT) device with

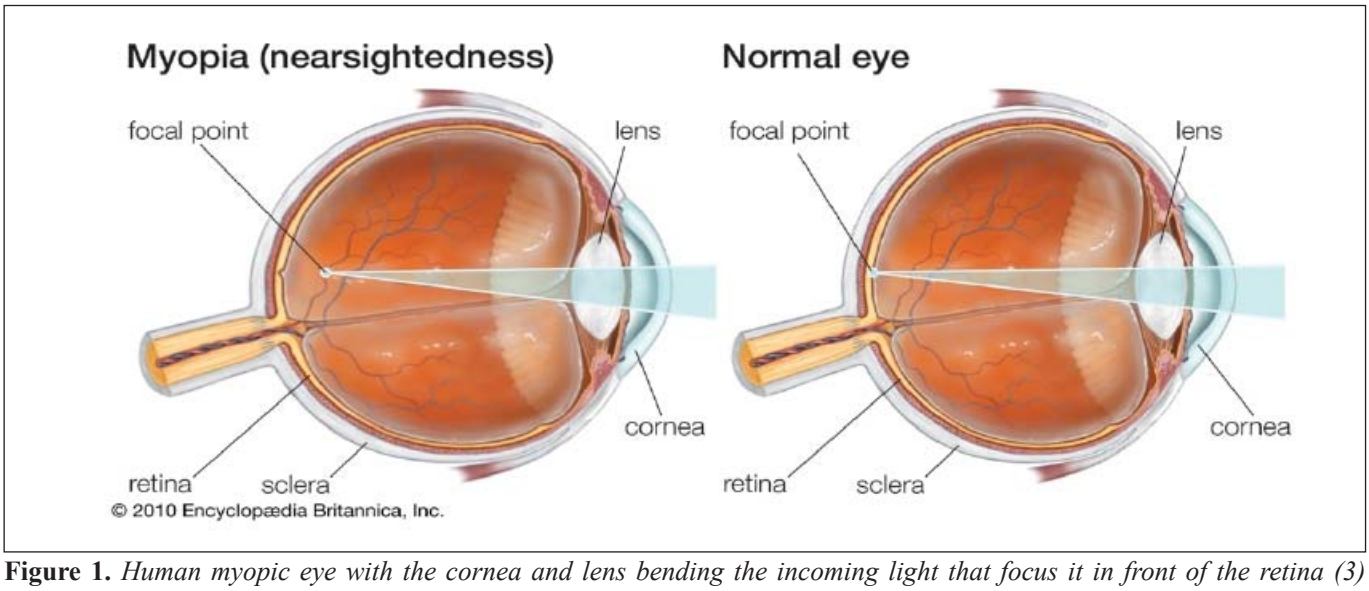

Figure 1. *Human myopic eye with the cornea and lens bending the incoming light that focus it in front of the retina (3) (Source: https://www.britannica.com).*

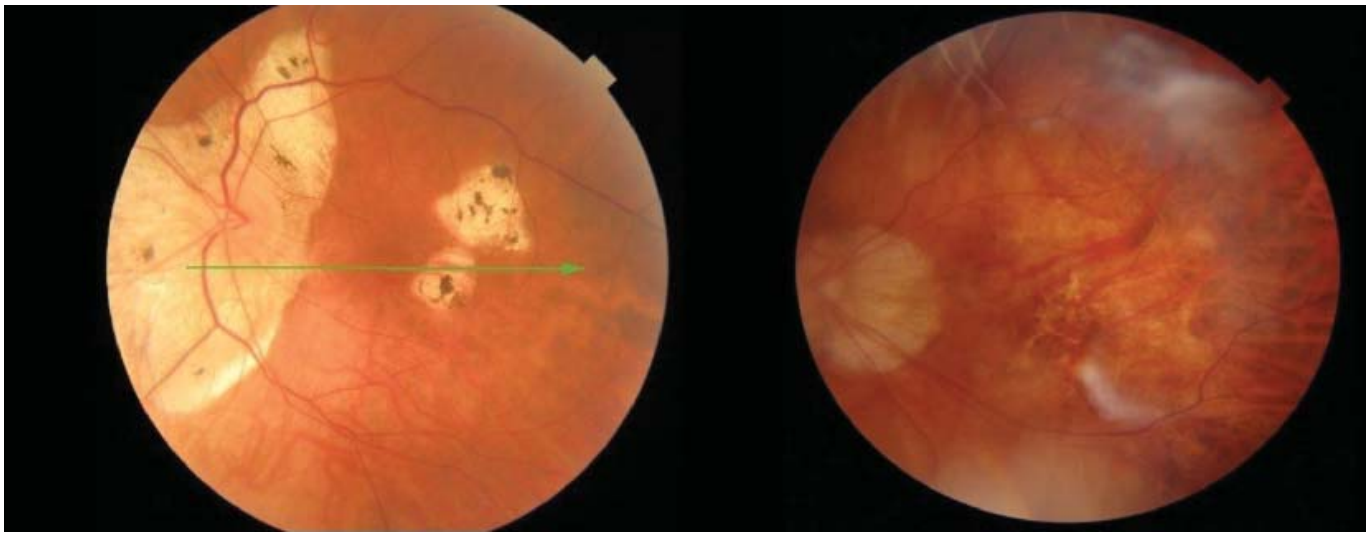

Figure 2. *Fundus images taken by DRI SS OCT device at our clinic (Right Picture shows existence of myopic conus and postetior staphyloma in a degenerative eye; Myopic conus and Fuchs spots on macula left Picture).*

34 subjects. The subjects had a mean age of 51 years old. Two independent observers performed all measurements. They compared inter-observer findings, choroidal thickness and area measurements with age, choroidal thickness with retinal foveal thickness. Their results showed that choroidal thickness and area measurements had a strong inter-observer correlation of 0.92 with $P < 0.001$. Area had a moderate negative correlation with age ($r = -0.62$, $P < 0.001$). Correlation between choroidal thickness and age was found $r = -0.61$. Mean choroidal thickness was the thinnest choroid nasally, thickening in the subfoveal region and then thinning again temporarily. Mean subfoveal choroidal thickness was found as 272 μm.

In a retrospective, observational case study, Pang and others investigated characteristics of extreme choroidal thinning in high myopia and its compatibility with good visual acuity.[16] They had 36 eyes of 20 patients with a subfoveal choroidal thickness of 20 mm or less. They showed that the mean retinal thickness was thinner in the fovea and parafoveal zones in highly myopic eyes and that choroidal thickness is not a reliable indicator of visual function. Yilmaz et al.[17] conducted a study on macular thickness measurements in healthy subjects by OCT device to determine changes with age and gender. They invited 100 patients with 200 eyes to be involved in this cross-sectional methodology.

Although similar studies were conducted on foveal and choroidal thickness, few studies were made on the relationships among the central foveal, subfoveal choroidal thicknesses of high myopia and degenerative patients. This was our main objective in terms of designing the current study. Our goal was to reveal how foveal and choroidal thicknesses were related to the subjects diagnosed with high myopia, degenerative eye disease, and what factors affect visual acuity the most in these patients. We also compared their results with a control group that included emmetropic subjects. The ages of the subjects ranged between 20 and 89 years. The median foveal thickness was found as 199.2 μm with a min-max range of 138-276 interval. Female subjects had thinner thickness. However, the thicknesses of their internal and external temporal quadrant were statistically thinner.

METHODS

Data were collected a total of 126 eyes with 73 patients in the Department of Ophthalmology at the Ankara Numune Training and Research Hospital in Turkey in 2017. Of them, 29 eyes with 18 had high myopia; 36 eyes with 24 degenerative myopia and 62 emmetropic eyes formed the control group. This study was designed as a retrospective case review of high myopia and degenerative myopia patients. Basic information about the subjects is shown in Table 1.

Table 1. *Demographic information about the subjects in the study.*

Groups	Number of the subjects (%)	Gender (M/F)	Number of eyes (%)	Average Age (Min-Max)
Degenerative myopia	24 (*33*)	9/15	36 (*29*)	47 (25-64)
High myopia	18 (*25*)	5/13	29 (*23*)	41 (18-60)
Control	31 (*42*)	11/20	61 (*48*)	41 (18-62)
Total	73	25/48	126	43 (18-64)

The subjects were purposefully included in this study based on some selection criteria. First, the subjects had no ocular pathologic disease e.g. cataract and no operation history related to refractive, glaucoma or vitreoretinal issues. Then, the subjects should have had some certain degree of refracted error as well as axial length criteria. For high myopia subjects, myopia had to be -6D or higher, have an axial length of longer than 26mm, and have mild degenerative signs. Degenerative group subjects had -6D or higher myopia and more than 6.5 mm axial length, and evident degenerative signs. Control group included emmetropic subjects and had not any eye disease history and low vision.

The participants, initially, underwent an ophthalmologic examination that included several measuring. Initially, their eyes were examined against systemic and ocular disease. Manifest refraction, axial length, central fovea, and subfoveal choroidal thicknesses were measured and compared. Also, fundus examination was conducted with a 90D lens. Central fovea and subfoveal choroidal thickness measurements were done by a swept source optic coherence tomography device (DRI HD-OCT Angio Triton SS). SS-OCT instrument has been used since 2010. It basically uses an adjustable 1050 nm single laser light that could scan eye with high wavelength. It also has better deeper penetration characteristics than spectral domain SD-OCT device. High myopia and degenerative myopia subjects were compared among the group and between the groups. They were also compared with the emmetropic group in terms of axial length and OCT findings. In study groups (high and degenerative myopia), the relationship between the axial length and the choroidal thickness were analyzed. Data analysis was completed with the SPSS 11.5 program. Paired t-test was used to evaluate the relationship among the groups.

RESULTS

Analyzed data showed various results in regard to refraction, axial length, fovea, and choroidal thickness measurements. We will briefly present major findings. Refraction (D), axial length (AXL) and spherical equivalence measurements for each group are summarized in Figure 3.

The measured values in above figure (3) showed that degenerative group had the highest refraction number (-17, $P < 0.001$) and high myopia group had half of that value (-8.15, $P < 0.001$). The difference between the degenerative group and high myopia group was smaller (1.55, 5%) in AXL measurement. The average spherical equivalence for the degenerative group (-17.12) was almost twice as much as for high myopia group (-8.15) (Figure 4).

Subfoveal choroidal thickness measurements for the subjects in each group are summarized in Figure 4. It shows that degenerative and high myopia subjects had thicker CFT than emmetropic subjects and conversely, they had much thinner SFCT. When degenerative and high myopia groups are compared, a difference between their CFT was not significant but SFCT values were significantly different (Figure 5).

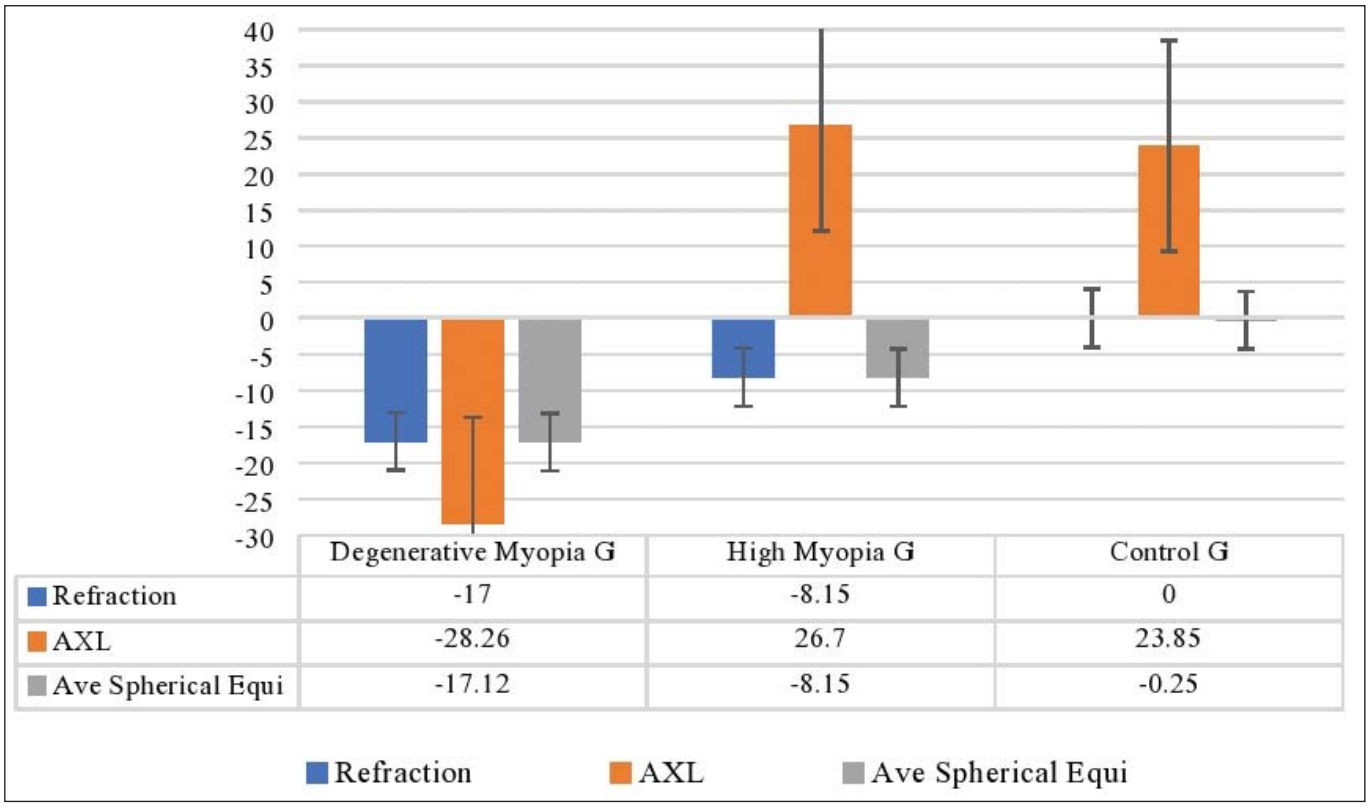

Figure 3. *Comparison of the refraction, AXL and Average spherical equivalence (P-value=0.001).*

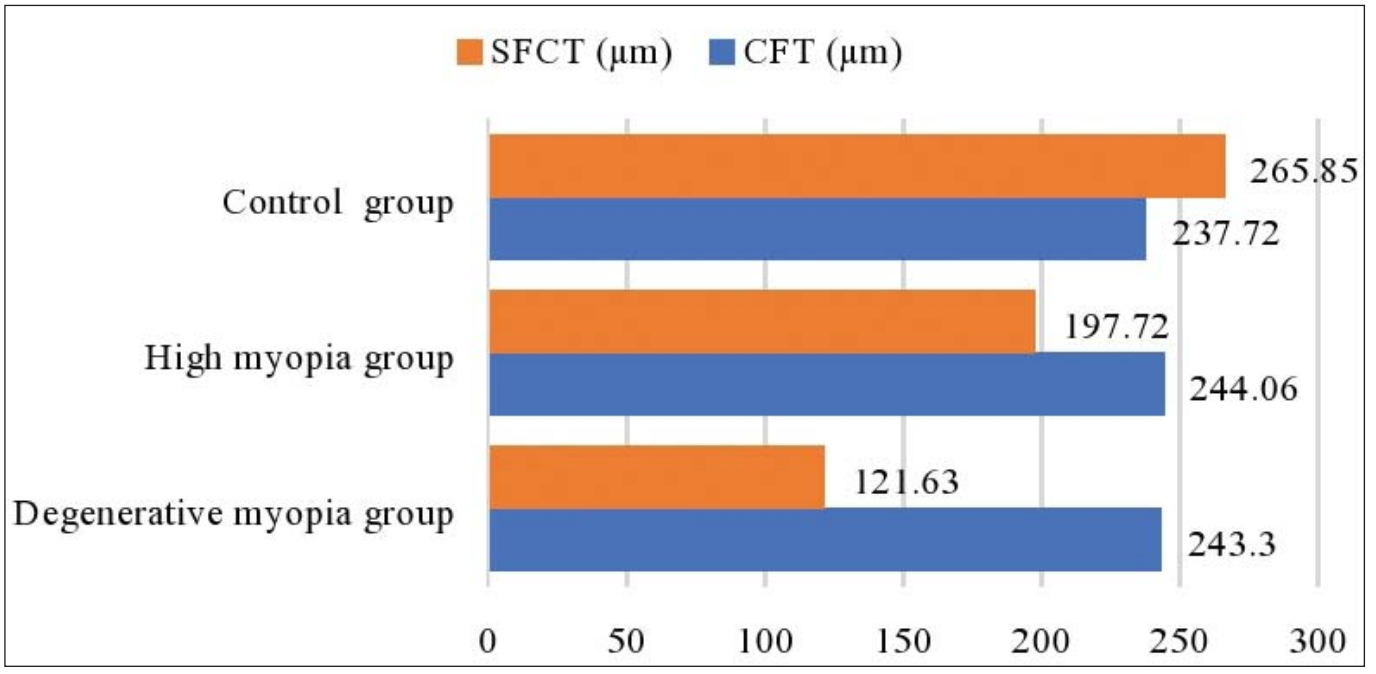

Figure 4. *Central foveal thickness and Subfoveal choroidal thickness (sfct) measurements for the subjects.*

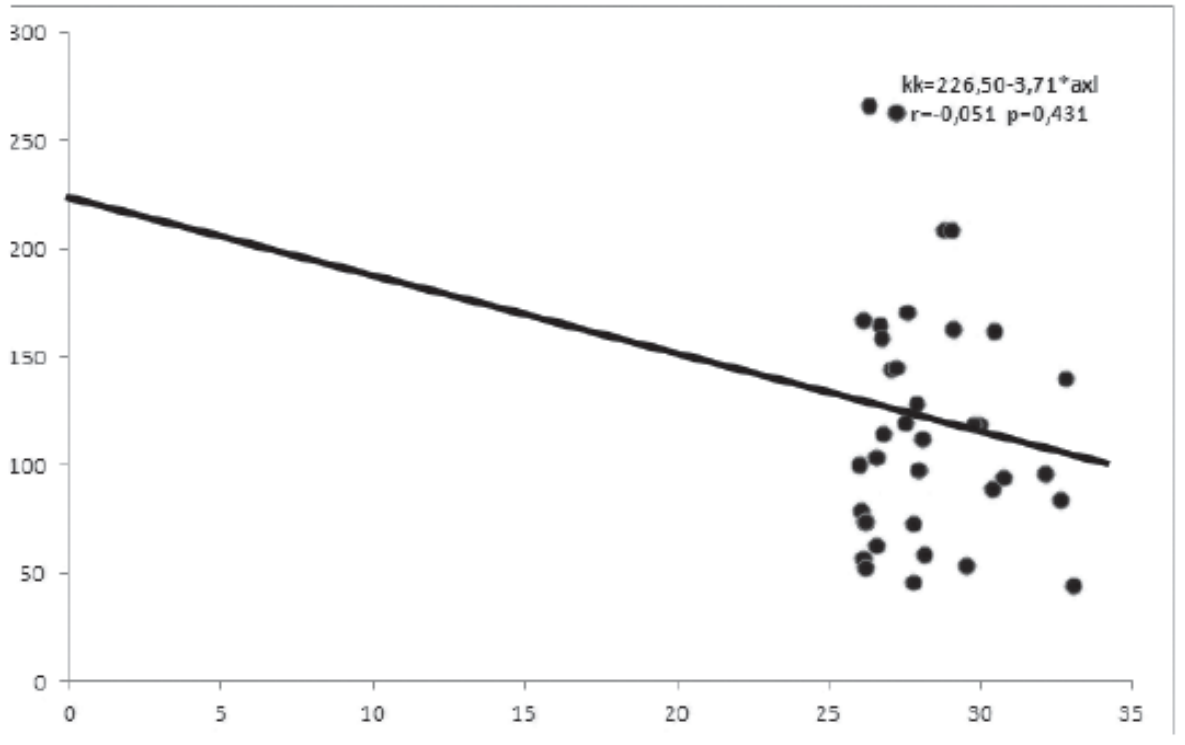

Figure 5. *The correlation between AXL and SFCT in the degenerative group.*

As can be seen in Figure 5, a weak negative correlation existed between AXL and SFCT values (r = -0.051, P = 0.431). (Figure 6).

Figure 6 showed that there was a relatively negative high (moderate) correlation (r = -0.459, P = 0.012) between AXL and SFCT values in the high myopia subjects. (Figure 7).

No significant difference and correlation was seen between AXL and SFCT values in the emmetropic subjects (Figure 3).

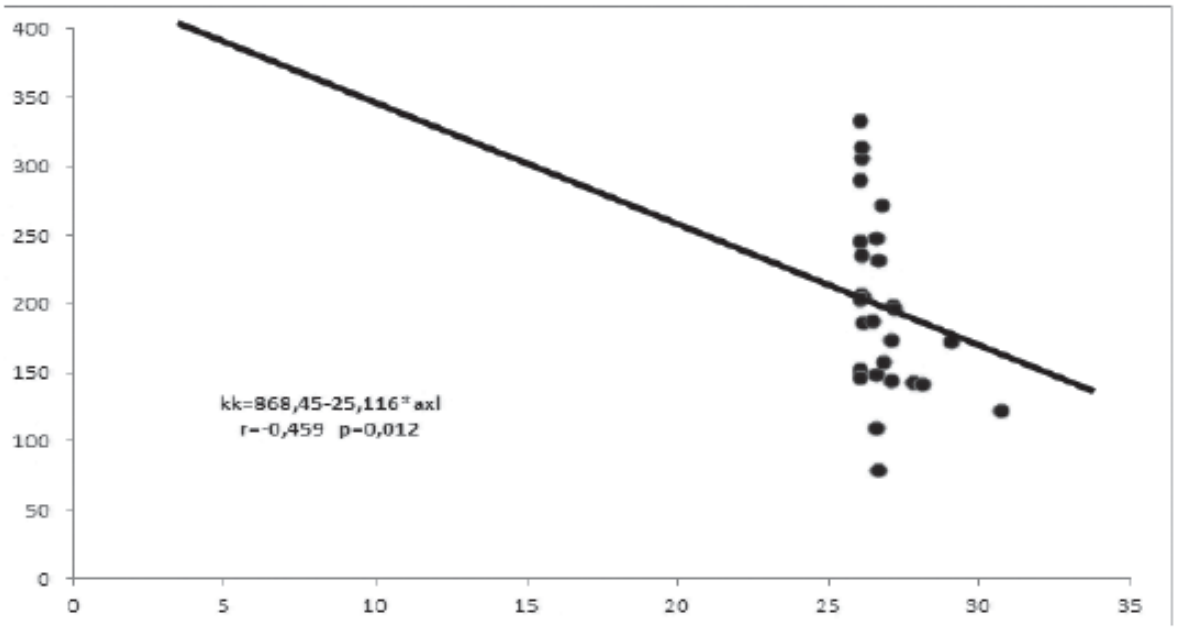

Figure 6. *The correlation between AXL and SFCT in the high myopia group.*

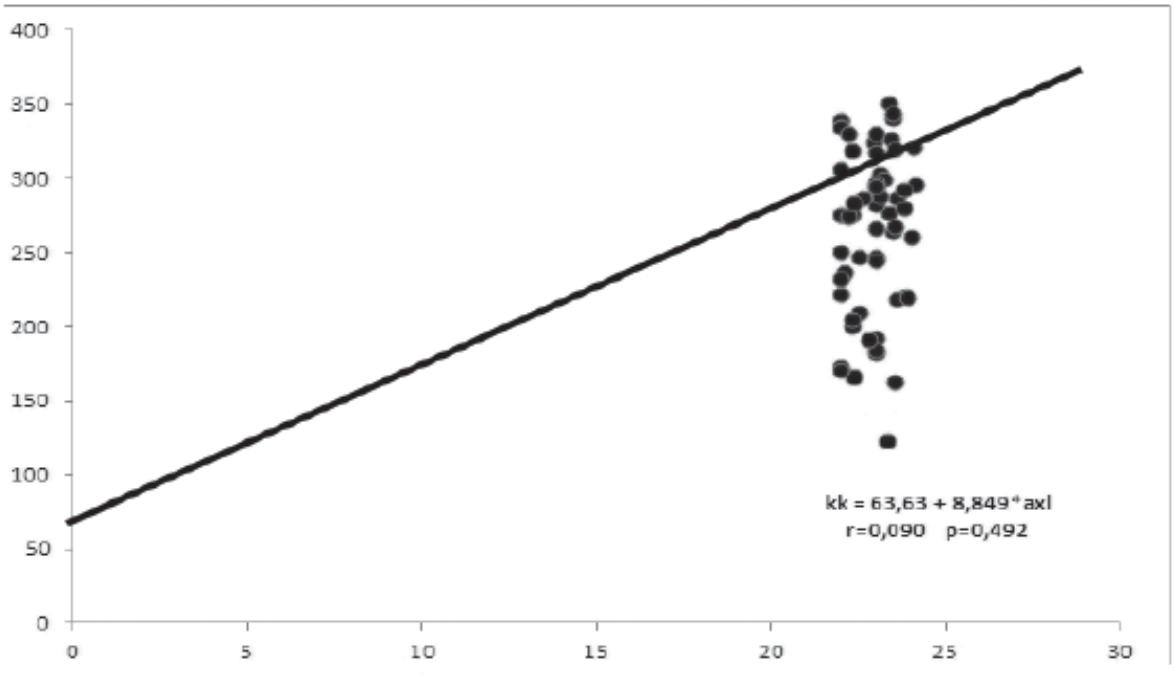

Figure 7. *The correlation between AXL and SFCT in the emmetropic group.*

CONCLUSION

Central foveal thickness (CFT)

Central foveal thickness (CFT) can vary depending on different geographical regions, race, and age groups; macular thickness may be different in high refractive defects.[17] CFT in healthy emmetropic eyes was measured as 197.1 µm (SD = 29.85).[18] Jin and others[20] found no significant difference among the thicknesses of emmetrope, myopic and hyperopia patients in a group of children participants. Similarly, other studies showed similarities of myopic and emmetropic eyes in terms of foveal thickness.[21]

There are some disagreements among the researchers about thickness changes in different regions of the macula in high myopia eyes.[21,22] For instance, Lam et al.[22] reported no significant difference in thickness of the internal macular

segment in different groups (high myopia, low-middle myopia, emmetropic eyes) in their study. Differently, Wu and others[21] claimed that the macular internal and external segments of the high myopic group were thinner than that of the non-myopic group. In similar studies,[23-27] the researchers suggested that the higher the degree of myopia, the higher median macular thickness, external macular segment thickness, and CFT.

The increase in CFT in high myopic eyes could possibly be improved by unhealthy fixation of the central fovea and extension of the outer segment of the photoreceptor layer.[25,26] The increase in AXL and CFT may also be related to retina-motor movement of the photoreceptors, which can be described as examples of deprivation myopia, formed by the closure of the eye.[26]

In our study, we found that the CFT did not change with increasing AXL and this result was supported by the previous research findings.[23-27]

Subfoveal Choroidal Thickness (SFCT)

The choroid is the vascular layer of the eye and supports the outer segment of the retina. The retinal pigment starts from the epithelium-Bruch's membrane junction and ends with the choroid-sclera junction. Choriocapillaris is made up of Haller layers with large veins. There few known about choroidal layers behind Choriocapillaris and the choroidal thickness varies from person to person. Since the development of OCT devices, choroidal thickness has been measured manually. Such devices measure choroidal thickness between Retinal pigment epithelium/Bruch membrane and the hyperreflective line, which shows the estimated end of large choroidal blood vessels.

Choroidal thickness varies with age, systemic and ocular diseases, refraction status and different times of the day. 1 mm increase in AXL causes 32 microns thinning in choroid thickness.[21] The choroidal thickness in myopic eyes is thinner than emmetropic eyes.[28,29]

According to our results, SFCT decreases as the axial length increases. This result is supported by many studies in the literature.[29,30] In addition, the highest and lowest choroidal thickness were found in the emmetropic group and the degenerative myopia group, respectively; both were statistically significant ($p = 0.000$). However, increased axial length alone did not affect best corrected visual acuity (BCVA) of high myopia subjects, while the increase in the degenerative findings significantly reduced BCVA.

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