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Evaluation of the Effect of Axial Length on Foveal Microstructure: A Comparative Optical Coherence Tomography Angiography Study

Comparative OCTA of Foveal Microstructure

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Abstract: Objective: Myopia, characterized by an increase in the eye's axial length, is a common refractive error that can lead to degenerative changes in the retina and optic nerve. The purpose of this study was to evaluate the effects of different axial length (AL) values on retinal and optic nerve head structures using Optical Coherence Tomography (OCT) and Optical Coherence Tomography Angiography (OCT-A).

Method: This prospective cross-sectional study, included 150 patients (150 eyes) with cataracts, aged between 18 and 69 were. Patients were divided into five groups based on their AL values. Following ophthalmological examination, retinal nerve fibre layer (RNFL) and ganglion cell complex (GCC+IPL) thicknesses were measured with OCT, while foveal and peripapillary vascular density were measured with OCT-A. The obtained data were statistically compared among the AL groups.

Results: The study revealed a significant thinning of RNFL and GCC+IPL thicknesses as AL increased ($p<0.05$). This thinning was particularly prominent in the nasal and inferior quadrants of the RNFL, and in the inferonasal and superotemporal quadrants of the GCC+IPL. In vascular density measurements, an increase in superficial and deep foveal density (SFD and DFD) values was observed as AL increased ($p<0.05$). This is thought to be due to the optical magnification effect caused the increade in axial length. No significant correlation was found between foveal avascular zone (FAZ) area and AL. Our findings supported that increasing axial length lead to thinning of neural tissue thicknesses of the retina and optic nerve, and this condition was associated with mechanical stress. The increase of vascular density detected in OCT-A measurements might be due to artefacts, indicating that caution should be exercised in the evaluating of vascular changes related to myopia.

Conclusion: This study confirms that axial elongation in myopia leads to thinning of the retinal neural tissues. Advanced imaging methods such as OCT and OCT-A are important tools for evaluating structural and vascular changes in myopic patients and for identifying potential complications at an early stage.

Keywords: Optical coherence tomography angiography, Myopia, Axial length.

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INTRODUCTION

Myopia is defined as a refractive error where parallel light rays entering the eye at rest are focused in front of the retina (1). Myopia is a widespread refractive error in the general population with a wide range of aetiology. There are many causes for the etiology of myopia. It is divided into two types according to its etiopathogenesis. If the axial lenght(AL) of the eye is longer than average, this defect is called axial myopia. If the refractive power of the eye is higher than normal, it is called refractive myopia (2). With the increase in AL, the retina, especially the posterior pole, shows microstructural degenerative changes. Myopia is a risk factor for various retinal pathologies, including retinal detachment, macular holes, choroidal neovascularisation, and retinoschisis. Myopia-related complications are among the leading causes of visual impairment (3).

Axial length is measured with A-scan biometry. The axial eye length of an adult human is mostly between 22 and 24.5 mm, with an average length of 23.6 mm (4). The difference in AL between the two eyes is generally not expected to exceed 0.3 mm (5).

Recently, OCT (SS-OCT) and Optical Coherence Tomography Angiography (OCTA) have gained clinical popularity. OCTA is a non-invasive imaging method that offers high resolution in visualising vascular changes. OCT is widely used in clinical and academic ophthalmology and has become indispensable in the diagnosis and treatment of high myopia and its complications with high-resolution cross-sectional retinal images (6). OCT allows measurements of the peripapillary retinal nerve fibre layer (RNFL) thickness analysis of the optic nerve head, macula and ganglion cell (GCA).

Early detection of changes in the intraretinal structures of a myopic eye is crucial. Identifying abnormal patterns of retinal structures will helps in evaluating early-stage, myopia-related complications (3).

The purpose of this study was to evaluate the effects of the increase in the eye's axial length on the retinal nerve fibre layer, ganglion cell complex, and optic nerve head blood supply with OCT and OCT-A

MATERIALS AND METHODS

This prospective cross-sectional study was conducted at the Adana City Training and Research Hospital between June 2020 and June 2021. A total of 150 eyes of 150 patients who presented to the Ophthalmology Clinic of Adana City Training and Research Hospital for cataracts were included in the study. This patient group was selected to adhere to ethical principles and avoid incurring additional healthcare costs, as they frequently undergo Optical Coherence Tomography Angiography (OCTA) as part of their routine clinical assessment.

Approval for this study was obtained from the Adana City Training and Research Hospital Clinical Research Ethics Committee (Date: 17.06.2020, Meeting No: 59, Decision No: 947). Informed consent was obtained from all patients. The study adhered to the principles of the Declaration of Helsinki, and no conflicts of interest were declared.

The inclusion criteria were: age between 18 and 69 years, willingness to participate in the study, no history of ocular diseases other than cataracts, and the ability to achieve adequate pupillary dilation and fixation for OCTA imaging.

Exclusion criteria included a history of ocular trauma or surgery; age under 18 or over 69; history of ocular diseases such as uveitis, glaucoma, tumors, or any retinal pathology; systemic diseases that could affect the vascular structure, such as diabetes mellitus, hypertension, coronary artery disease, or vasculitis; corneal surface problems; media opacities, such as significant lens denseness, that would reduce image quality and preclude accurate measurements; intraocular pressure outside the range of 12-20 mmHg; OCTA and OCT image signal strength (scan quality) below 6/10; pregnancy; a history of systemic or ocular medication use; and a history of smoking, alcohol, or substance abuse.

During data collection, the age, sex, and the studied eye of each participant were recorded. The ophthalmological examination included

measurement of best-corrected visual acuity (BCVA) using a Snellen chart (expressed as a decimal value), measurement of intraocular pressure (IOP) with applanation tonometry, and a fundoscopic examination following pupillary dilation. This was performed using a +90 D non-contact lens to screen the optic disc, macula, and peripheral retina for any degeneration, lesions, or other pathologies. Following the examination, optical biometry (IOLMaster, Carl Zeiss AG, Germany), OCTA (AngioVue RTVue-XR, Optovue, Inc.; Fremont; California, USA) and OCT examination (Carl Zeiss Meditec, Inc., CA) were performed.

Based on the AL values obtained from biometry, participants were divided into five groups:

Group 1: AL < 22 mm

Group 2: AL 22.00–22.99 mm

Group 3: AL 23.00–23.99 mm

Group 4: AL 24.00–24.99 mm

Group 5: AL ≥ 25 mm

Studies in the literature have used groupings with 1 mm, 1.5 mm, and 2 mm differences. Narrower intervals facilitate the detection of subtle changes in parameters related to AL, Therefore, a 1 mm interval was used for grouping in our study (7,8,9,10,11).

The biometric measurements of the patients, including axial length (AL), anterior chamber depth (ACD), and keratometry values, were measured using the IOL-Master (Carl Zeiss Meditec, La Jolla, CA, USA).

OCTA scans were performed using the AngioVue® (RTVue-XR, Fremont, California, USA) device, a dual-modality OCT system that provides both structural and vascular measurements. For all patients, fovea-centered 3x3 mm macular scans and 4.5x4.5 mm optic disc scans were acquired and evaluated. However, the OCTA device used in this study lacks a magnification correction feature, which can lead to deviations in patients with axial lengths above and below 23.95 mm.

Vascular density (%) was measured in the superficial and deep capillary plexuses within an area divided by 1 mm and 3 mm diameter circles centered on the foveal avascular zone (FAZ), corresponding to the foveal and parafoveal regions. Each region was also divided into four equal quadrants: temporal, superior, nasal, and inferior.

Central macular thickness was automatically measured by the device by selecting the Quickvue module, which calculates the distance between the internal limiting membrane (ILM) and the retinal pigment epithelium (RPE). The 3x3 mm scan was segmented into a 1 mm central foveal ring and a surrounding concentric ring divided into four quadrants (totaling 5 zones).

For the optic nerve head, whole image vessel density, inside disc vessel density, and peripapillary capillary vascular density (PPCVD) were calculated by the software. In our study, whole image density, inside disc density, peripapillary density (PPD), PPD for the inferior and superior hemispheres, and PPD for the superior, temporal, inferior, and nasal quadrants were calculated. Additionally, to evaluate the microvascular structure, the capillary vessel densities within these measurement areas were used as a study parameter. In the optic disc mode, the peripapillary retinal nerve fibre layer thickness (pRNFLT) within a 3.45 mm diameter circle around the optic disc was also evaluated.

GCA was performed in six sectors around the macula: superotemporal, superior, superonasal, inferonasal, inferior, and inferotemporal.

Statistical analysis of the data was performed using the SPSS (Statistical Package for the Social Sciences) version 23.0 software package. Categorical measurements were summarized as numbers and percentages, while continuous measurements were summarized as mean and standard deviation (or median and minimum-maximum where appropriate). The Shapiro-Wilk test was used to determine whether the parameters followed a normal distribution. For comparisons between groups, the One-way ANOVA test was used for normally distributed parameters, and the Kruskal-Wallis test was used for non-normally distributed

parameters. To identify the source of intergroup differences, the Bonferroni test was used as a post-hoc test for normally distributed parameters with equal variances, while Dunn's test with Bonferroni correction was used as a post-hoc test for non-normally distributed parameters. A p-value of less than 0.05 was considered statistically significant for all tests.

RESULTS

One hundred fifty eyes of 150 patients were included in our study. A total of 150 patients were included, with 30 patients in each group based on their axial lengths: under 22 mm, 22-22.99 mm, 23-23.99 mm, 24-24.99 mm, and 25 mm and above. It was determined that 51.3% (n=77) of the patients were male and 48.7% (n=73) were female. The average age of the patients was found to be 44.3±11.1 years (Min: 18, Max: 69). The eye included in the study was the right eye in 53.3% (n=80) of the patients and the left eye in 46.7% (n=70). The mean axial length was observed to be 23.56±1.61 (Min: 19.72, Max: 27.12) in the patients.

Table 1 summarizes the findings obtained from the average OCT-A measurements of all patients included in the study.

Table 1. Average FAZ, AI, FD, CMT values, and average OCT-A measurements of the optic disc and its surroundings for all patients.

Parameter	Mean±sd	Med (Min-Max)
Faz	0,29 ± 0,09	0,28 (0,05-0,55)
AI	1,13 ± 0,04	1,13 (1,06-1,26)
FD	51,89 ± 3,82	52,18 (39,66-60,05)
CMT	218,25 ± 17,64	216 (181-276)
Whole Image (%)	50,55 ± 3,42	50,4 (43,3-80)
Inside disc (%)	51,94 ± 5,45	53,4 (34,6-64,2)
PPCVD (%)	52,41 ± 2,76	52,3 (44,4-58,4)
Superior Half PPCVD	52,69 ± 2,83	53 (44-61)
Inferior Half PPCVD	52,35 ± 4,41	52 (42-90)
Superior PPCVD	52,12 ± 4,54	52 (32-63)
Temporal PPCVD	50,66 ± 5,22	52 (33-61)
Inferior PPCVD	53,65 ± 3,64	54 (43-63)
Nasal PPCVD	53,79 ± 5,49	53 (42-68)

FAZ: Foveal avascular zone AI: Acircularity Index FD: Foveal density CMT: Central macular thickness PPCVD: Peripapillary capillary vascular density

Table 2 shows that the groups were similar in terms of the demographic characteristics examined (gender, studied eye, and age).

Table 2. Comparison of Demographic Characteristics of the Groups

	<22 mm (a)	22-22,99 mm (b)	23-23,99 mm (c)	24-24,99 mm (d)	>25 mm (e)	p
	n(%)	n(%)	n(%)	n(%)	n(%)	
Sex						
Male	17 (56,7)	16 (53,3)	16 (53,3)	14 (46,7)	17 (56,7)	0,938
Female	13 (43,3)	14 (46,7)	14 (46,7)	16 (53,3)	13 (43,3)	
Eye						
Right Eye	14 (46,7)	14 (46,7)	14 (46,7)	22 (73,3)	13 (43,3)	0,118
Left Eye	16 (53,3)	16 (53,3)	16 (53,3)	8 (26,7)	17 (56,7)	
	Mean±sd	**Mean±sd**	**Mean±sd**	**Mean±sd**	**Mean±sd**	**p**
Age	43,27±10,68	47,07±12,39	43,97±12,22	47,90±10,58	39,33±7,19	0,109

* p<0,05, chi square test, Oneway Anova test, Bonferroni test

In Table 3, the differences between the groups were examined with OCT-A measurements. The analysis found that the differences in SPD (p=0.168), TEMPORAL SPD (p=0.147), SUPERIOR SPD (p=0.153), NASAL SPD (p=0.676), and INFERIOR SPD (p=0.365) measurements between the groups were not statistically significant (p>0.05). A significant difference was detected between the groups in the SFD (p=0.005) value (p<0.05) (Table 3).

The source of the difference found in the SFD value was that patients with an AL of 25 mm and above had a higher measurement value compared to the patients in the 22-22.99 mm and 23-23.99 mm groups (p<0.05) (Table 3).

Table 3. Examination of Differences Between Groups with OCTA Superficial Vascular Density Measurements

	<22 mm (a)	22-22,99 mm (b)	23-23,99 mm (c)	24-24,99 mm (d)	>25 mm (e)	p	Post Hoc p
SFD (F)	16,800 [9,55]	14,250 [4,80]	14,800 [7,65]	15,050 [8,90]	19,900 [5,78]	**0,005**	e-b; p=0,007 e-c; p=0,010
SPD (χ2)	50,700 [2,88]	51,450 [3,70]	52,400 [3,98]	52,400 [3,52]	52,400 [6,13]	0,168	
TEMPORAL SPD (χ2)	48,800 [3,27]	49,250 [4,12]	50,400 [4,68]	49,800 [2,88]	50,100 [4,30]	0,147	
SUPERIOR SPD (χ2)	52,300 [3,85]	53,400 [3,00]	53,450 [4,63]	53,450 [4,45]	54,950 [5,72]	0,153	
NASAL SPD (χ2)	50,150 [4,85]	50,650 [3,85]	51,050 [4,10]	51,00 [4,95]	51,850 [7,87]	0,676	
INFERIOR SPD (χ2)	52,650 [2,40]	52,700 [4,25]	53,150 [3,30]	53,050 [4,08]	53,450 [5,90]	0,365	

*p<0.05, **χ2:** Kruskal-Wallis test, **F:** Oneway ANOVA test, Post Hoc Bonferroni and Tamhane's T2 tests

In Table 4, the differences between the groups were examined with OCT-A measurements. The analysis found that the differences in DPD (p=0.335), TEMPORAL DPD (p=0.662), SUPERIOR DPD (p=0.117), NASAL DPD (p=0.641), and INFERIOR DPD (p=0.297) measurements between the groups were not statistically significant (p>0.05). A significant difference was detected between the groups in the DFD (p=0.016) value (p<0.05) (Table 4).

The source of the difference found in the DFD value was that patients with an AL of 25 mm and above had a higher measurement value compared to the patients in the 22-22.99 mm and 23-23.99 mm groups (p<0.05) (Table 4).

Table 4. Examination of Differences Between Groups with OCTA Deep Vascular Density Measurements

	<22 mm (a)	22-22,99 mm (b)	23-23,99 mm (c)	24-24,99 mm (d)	>25 mm (e)	p	Post Hoc p
DFD (F)	34,500 [14,72]	31,100 [9,08]	33,050 [9,68]	34,700 [10,93]	38,400 [8,20]	**0,016**	e-b; p=0,032 e-c; p=0,033
DPD (χ2)	55,850 [4,82]	56,750 [5,12]	57,300 [3,40]	56,350 [4,58]	57,050 [5,38]	0,335	
TEMPORAL DPD (F)	56,200 [4,80]	57,150 [4,72]	56,500 [3,88]	56,650 [4,55]	56,950 [3,60]	0,662	
SUPERIOR DPD (χ2)	56,00 [5,78]	57,400 [5,85]	57,400 [4,00]	54,95 [5,00]	57,35 [6,38]	0,117	
NASAL DPD (χ2)	56,55 [4,23]	57,50 [4,63]	57,60 [3,38]	56,85 [4,90]	57,75 [4,85]	0,641	
INFERIOR DPD (χ2)	56,05 [5,00]	56,95 [4,43]	57,35 [4,52]	56,35 [5,68]	56,50 [6,47]	0,297	

*p<0.05, **χ2:** Kruskal-Wallis test, **F:** Oneway ANOVA test, Post Hoc Bonferroni and Tamhane's T2 tests

In the GCL+IPL measurements presented in Table 5, it was found that the differences between the groups were significant for the average (p<0.001), superior (p<0.001), superotemporal (p<0.001), inferotemporal (p=0.001), inferior (p=0.007), inferonasal (p<0.001), and superonasal quadrant (p=0.002) values (p<0.05).

It was found that the observed differences in the average and inferonasal quadrant GCL+IPL measurements were due to the fact that patients with an AL of 25 mm and above had lower values than those with an AL of under 22 mm and in the 22-22.99 mm group (p<0.05).

The source of the difference found in the GCL+IPL superior quadrant was that patients with an AL under 22 mm had higher values than those with an AL in the 23-23.99 mm group and 25 mm and above group (p<0.05).

The source of the difference observed in the superotemporal (p<0.001) and inferotemporal (p=0.001) quadrant measurements obtained from GCL+IPL measurements was determined to be that those with an AL of 25 mm and above had lower values than those with an AL of under 22 mm, between 22-22.99 mm, and between 23-23.99 mm (p<0.05).

The source of the observed difference in the inferior and superonasal quadrant measurements was determined to be that those with an AL of under 22 mm had higher values than those with an AL of 25 mm and above (p<0.05) (Table 5).

Table 5. Examination of Differences Between Groups with GCL+IPL Measurements

	<22 mm (a)	22-22,99 mm (b)	23-23,99 mm (c)	24-24,99 mm (d)	>25 mm (e)	p	Post Hoc p
GCL+IPL MEAN (F)	87,5 [7,5]	84,5 [8]	84,5 [18]	85 [5,25]	80 [10]	**<0,001**	a-e; p<0,001 b-e; p=0,039
GCL+IPL S (F)	88 [9]	85,5 [8,25]	84 [9]	85,5 [5,25]	82 [9]	**<0,001**	a-c; p=0,013 a-e; p<0,001
GCL+IPL ST (F)	86,5 [7,75]	84 [8]	82,5[6,5]	85,5 [7]	79 [8,5]	**<0,001**	a-e; p<0,001 b-e; p=0,003 c-e; p<0,001
GCL+IPL IT (F)	83,5 [8,75]	81 [8,25]	81 [7,25]	82,5 [6,25]	79 [9]	**0,001**	a-e; p<0,001 b-e; p=0,030 c-e; p=0,016
GCL+IPL I (χ2)	88,5 [11,5]	85 [9,5]	83,5 [7,25]	83 [7,25]	79 [12]	**0,007**	a-e; p=0,039
GCL+IPL IN (χ2)	87 [9,75]	83,5 [5,25]	84,5 [8,25]	84 [6,25]	80 [8]	**<0,001**	a-e; p=0,001 b-e; p=0,012
GCL+IPL SN (F)	88,5 [10,75]	86,5 [7,25]	85 [9,5]	85 [7,25]	79 [11]	**0,002**	a-e; p=0,001

*p<0.05, **χ2:** Kruskal-Wallis test, **F:** Oneway ANOVA test, Post Hoc Bonferroni and Tamhane's T2 tests **GCL+IPL:** Ganglion cell layer and inner plexiform layer, **AVG:** average, **S:** superior, **ST:** superotemporal, **IT:** inferotemporal, **I:** inferior, **IN:** inferonasal, **SN:** superonasal

In Table 6, the differences in RNFL thickness measurements between the groups were examined. The analysis found that the differences in PPRNFL (p<0.001), superior half (p=0.002), inferior half (p<0.001), superior quadrant (p=0.009), temporal quadrant (p=0.026), inferior quadrant (p<0.001), and nasal quadrant (p<0.001) values between the groups were statistically significant (p<0.05) (Table 6). When the source of the difference between the groups in RNFL thickness measurements was examined:

The difference observed in the PPRNFL value was found to be due to those with an axial length of less than 22 mm having a higher value than those with an axial length of 23-23.99 mm (p=0.002) and 25 mm and above (p=0.021); it was also found that those with an axial length between 22-22.99 mm had a higher value than those between 23-23.99 mm (p=0.033) (p<0.05).

The source of the difference found in the RNFL superior half and superior quadrant values was determined to be that those with an axial length of less than 22 mm had a higher value than those with an axial length of 23-23.99 mm (p<0.05).

The difference found in the RNFL inferior half value was determined to be due to those with an AL of less than 22 mm having a higher value than those with an AL of 23-23.99 mm (p=0.005) and 25 mm and above (p=0.012) (p<0.05).

The source of the difference found in the RNFL temporal quadrant value was determined to be that those with an AL between 23-23.99 mm had a lower value than those with an AL of less than 22 mm (p=0.047) and those between 24-24.99 mm (p<0.05).

The source of the difference observed in the RNFL inferior quadrant value was found to be due to those with an AL of less than 22 mm and those between 22-22.99 mm having a higher value than those with an AL of 23-23.99 mm and 25 mm and above (p<0.05).

In the differences detected between the groups with the RNFL nasal quadrant value, it was found that those with an AL of less than 22 mm had a higher value than those with an AL of 23-23.99 mm, 24-24.99 mm, and 25 mm and above (p<0.05).

Table 6. Examination of Differences Between Groups with RNFL Thickness Measurements

	<22 mm (a)	22-22,99 mm (b)	23-23,99 mm (c)	24-24,99 mm (d)	>25 mm (e)	p	Post Hoc p
PPRNFL(µm)	108,00 [22,50]	101,000 [18,25]	94,500 [12,5]	97,00 [13]	94,50 [14,50]	**<0,001**	a-c; p=0,002 a-e; p=0,021 b-c; p=0,033
Superior Half	105,00 [16,25]	101,00 [15,25]	93,00 [14,25]	97,50 [8,50]	95,00 [17,00]	**0,002**	a-c; p=0,007
Inferior Half	109,00 [24,75]	100,00 [17,50]	93,00 [16,50]	97,00 [16,25]	94,500 [11,00]	**<0,001**	a-c; p=0,005 a-e; p=0,012
Superior	124,5 [86,181]	123 [85,179]	109,5 [84,146]	117 [93,150]	111,5 [88,140]	**0,009**	a-c; p=0,041
Temporal	66,0 [18,75]	67,0 [16,25]	61,0 [10,50]	67,0 [13,25]	67,0 [12,75]	**0,026**	a-c; p=0,047 d-c; p=0,035
Inferior	137,50 [29,50]	135,00 [26,50]	118,50 [19,75]	125,500 [22,25]	116,500 [18]	**<0,001**	a-c; p=0,046 a-e; p=0,012 b-c; p=0,031 b-e; p=0,005
Nasal	99,00 [20,50]	93,00 [20,0]	82,50 [22,0]	82,50 [17,50]	84,00 [24,50]	**<0,001**	a-c; p=0,002 a-d; p=0,003 a-e; p=0,025

DISCUSSION

The aim of this study is to evaluate the effects of AL on different ocular structures using OCT-A. Our findings show that increased AL, which is associated with higher degrees of myopia, leads to significant changes in the microvascular structures of the retina and optic nerve head, as well as in neural tissue thicknesses. These results are consistent with the existing literature on morphological changes observed in myopic eyes.

Evaluation of Foveal Area and Vascular Density findings in our study, no statistically significant relationship was found between the FAZ area and AL. This finding is similar to previous studies by Min et al. (12) and Ucak et al. (13). Although FAZ measurement has been reported as a reliable follow-up tool in healthy eyes (14), the automatic calculation method of the OCT-A device used in our study, and the fact that the data were not separated into superficial and deep capillary plexuses, can be considered a limitation. While the literature discusses potential effects of age and sex on FAZ area (15, 16), the absence of significant demographic differences between our patient groups reduces the likelihood that our results were influenced by these factors.

However, a positive correlation was found between superficial foveal density (SFD) and deep foveal density (DFD) values and AL (SFD: p=0.005; DFD: p=0.016). This finding differs from other studies, such as Yang et al. (17), which reported a negative correlation between axial length and vascular density. We believe this difference may be related to optical magnification in eyes with high AL, which causes the imaging field to expand and thus results in higher-than-actual density values. As AL increases, magnification in the imaging system also increases. This can cause anatomical structures in OCT-A images to appear sparser than they actually are (18). However, since the device algorithms that calculate vascular density operate based on a fixed measurement area, ignoring this magnification effect may lead to the interpretation that vascular structures are closer together. Consequently, structures that are expected to be sparser may be erroneously reported as having higher density values. The default AL setting of 23.95 mm in the device used in our study may have made this artifact more pronounced in eyes with longer actual AL (19). The fact that most studies in the literature have examined only myopic groups and excluded eyes with short AL

may be another reason for the different results in our study. By including groups with a wide range of AL in these comparisons, our study makes an important contribution to the literature.

Relationship Between Neural Tissue Thickness and Axial Length in our results show that the thickness of the ganglion cell layer and inner plexiform layer (GCL+IPL) is negatively correlated with AL, and this relationship is statistically significant in all sectors ($p<0.05$). This finding is fully consistent with studies by Dhami et al. (21) and Tham et al. (20), which reported that mechanical stretching and retinal thinning due to axial elongation lead to a decrease in GCL+IPL thickness. Since GCL+IPL thinning may be an early indicator of glaucoma, our findings again emphasize the need for clinicians to consider axial length when interpreting these results in myopic patients.

Similarly, RNFL thickness also decreased with increasing AL. In particular, pRNFL thickness in the superior and inferior hemispheres, as well as in the nasal and inferior quadrants, showed a negative correlation with axial length ($p<0.05$). These results are similar to studies by Singh et al. (22) and Hashemi et al. (23), which suggested that the decrease in RNFL thickness is related to the spreading of nerve fibres over a larger area or mechanical damage due to stretching as a result of axial elongation. Some studies (24, 25) have found a positive correlation in the temporal quadrant within Asian populations; however, our study detected a different relationship in this quadrant. RNFL thickness was found to be significantly lower in the 23-23.99 mm AL group compared to both shorter and longer AL groups. This may indicate genetic or structural differences between populations.

Many studies in the literature have shown that as AL increases, the pRNFL and GCC become thinner. Our findings clearly demonstrate that in myopic eyes, RNFL and GCL+IPL thickness decrease with increasing axial length (22). This thinning is a physiological adaptation resulting from elongation of the eye. However, this presents an important challenge for clinicians: distinguishing the generalized thinning in a myopic eye from localized, pathological damage caused by glaucoma is crucial.

Limitations

The primary limitation of this study is the small number of patients with high AL (AL > 26 mm). This is due to factors such as the COVID-19 pandemic and a lower prevalence of high myopia in our population compared to Asian populations. This may have prevented us from fully determining the effect of axial elongation on vascular density. However, our study distinguishes itself from similar studies in the literature by including individuals with short AL, thereby comparing different AL groups. The OCTA device we used employs a default AL of 23.95 mm. If the actual AL differs from this, the device's image measurements will be inaccurate. This is the biggest limitation of our study.

Another limitation is that, although age is known to affect retinal parameters, we did not perform subgroup analyses based on narrower age ranges (e.g., 18-35, 36-49, 50-65 years). While we observed weak to moderate correlations ($r = -0.168$ to -0.409) between age and some parameters, no significant relationship was found between age and most parameters. Further grouping by age would increase the complexity of the results and reduce clarity. For this reason, detailed subgroup analyses based on age were not performed. Additionally, our study is cross-sectional and may not fully represent the general population.

Conclusion and Recommendations

This study has shown that evaluating the structural features of the retina and optic nerve head in different AL groups using OCT-A and other parameters is an important tool for understanding myopic changes. Our findings suggest that in highly myopic eyes, GCL+IPL and RNFL are significantly affected, and these changes may be related to mechanical factors caused by the elongation of the eye.

These results emphasize that axial length is a critical factor in the diagnosis and monitoring of diseases like glaucoma in myopic patients. Monitoring OCTA parameters is an effective tool to protect highly myopic eyes from myopic complications.

Future studies should validate these findings with larger patient groups and investigate the long-term effects of myopia progression on these parameters.

REFERENCES

1. Warner N. Update on myopia. Curr Opin Ophthalmol. 2016;27(5):402-6.
2. Schuman JS. Spectral domain optical coherence tomography for glaucoma (an AOS thesis). Trans Am Ophthalmol Soc. 2008;106:426-51.
3. Venkatesh R, Sinha S, Gangadharaiah D, Gadde SGK, Anitha V, Bhartiya S, et al. Retinal structural-vascular-functional relationship using optical coherence tomography and optical coherence tomography – angiography in myopia. Eye Vis (Lond). 2019;6:8.
4. Başar E. Miyopi. In: İÜ Cerrahpaşa Tıp Fakültesi Sürekli Tıp Eğitimi Etkinlikleri. 2005. p. 147–50.
5. Olsen T, Nielsen PJ. Immersion versus contact in the measurements of axial length. Acta Ophthalmol (Copenh). 1989;67(1):101-2.
6. Christenbury JG, Klufas MA, Sauer TC, Sarraf D. OCT Angiography of Paracentral Acute Middle Maculopathy Associated With Central Retinal Artery Occlusion and Deep Capillary Ischemia. Ophthalmic Surg Lasers Imaging Retina. 2015;46(5):579-81.
7. Zheng X, He HL, Zhang HB, Liu SH. The relationship between axial length and spherical equivalent refraction in Chinese children. Optom Vis Sci. 2012;89(11):1622–7.
8. Luo HD, Gazzard G, Fong A, Aung T, Hoh ST, Loon SC, et al. Myopia, axial length, and OCT characteristics of the macula in Singaporean children. Invest Ophthalmol Vis Sci. 2006;47(7):2773-81.
9. Kayabaşi M, et al. The Effect of Axial Length on Macular Vascular Density in Eyes with High Myopia. Rom J Ophthalmol. 2025;69(1):88-100.
10. Nixon A, et al. Ratio of Refractive Error Change to Axial Elongation in Young Myopes. Optom Vis Sci. 2022;99(3):277-84.
11. 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):7578-86.
12. Min CH, Al-Qattan HM, Lee JY, et al. Macular Microvasculature in High Myopia without Pathologic Changes: An Optical Coherence Tomography Angiography Study. Korean J Ophthalmol. 2020;34(2):106-12.
13. Ucak T, Icel E, Yilmaz H, et al. Alterations in optical coherence tomography angiography findings in patients with high myopia. Eye (Lond). 2020;34(6):1129-35.
14. Carpineto P, Mastropasqua R, Marchini G, Toto L, Di Nicola M, et al. Reproducibility and repeatability of foveal avascular zone measurements in healthy subjects by optical coherence tomography angiography. Br J Ophthalmol. 2016;100(5):671-6.
15. Samara WA, Say EAT, Khoo CTL, et al. Correlation of foveal avascular zone size with foveal morphology in normal eyes using optical coherence tomography angiography. Retina. 2015;35(11):2188-95.
16. Gómez-Ulla F, Cutrin P, et al. Age and Gender Influence on Foveal Avascular Zone in Healthy Eyes. Exp Eye Res. 2019;189:107856.
17. Yang Y, Wang J, Jiang H, et al. Retinal Microvasculature Alteration in High Myopia. Invest Ophthalmol Vis Sci. 2016;57:6020–30.
18. Drexler W, Fujimoto JG. Optical Coherence Tomography: Principles and Applications with CD-ROM. Springer Science & Business Media; 2008.
19. Tan C, Huang S, Liu J, et al. Evaluation of Peripapillary Retinal Nerve Fiber Layer Thickness in Normal and Myopic Eyes Using Optical Coherence Tomography. PLoS One. 2014;9(2):e88543.
20. Dhami A, Dhasmana R, Nagpal RC. Correlation of Retinal Nerve Fiber Layer Thickness and Axial Length on Fourier Domain Optical Coherence Tomography. J Clin Diagn Res. 2016;10(4):NC15-7.
21. Tham YC, Chee ML, Dai W, et al. Profiles of Ganglion Cell-Inner Plexiform Layer Thickness in a Multi-Ethnic Asian Population. Ophthalmology. 2020;127(8):1064-76.
22. Singh D, Mishra SK, Agarwal E, et al. Effect of myopia on the thickness of the retinal nerve fiber layer measured by Cirrus HD optical coherence tomography. Invest Ophthalmol Vis Sci. 2010;51(8):4075-83.
23. Hashemi H, Khabazkhoob M, Nabovati P, et al. Retinal nerve fibre layer thickness in a general population in Iran. Clin Exp Ophthalmol. 2017;45(3):261-9.
24. Knight OJ, Girkin CA, Budenz DL, et al. Effect of Race, Age, and Axial Length on Optic Nerve Head Parameters and Retinal Nerve Fiber Layer Thickness Measured by Cirrus HD-OCT. Arch Ophthalmol. 2012;130(3):312-8.
25. Kim MJ, Lee EJ, Kim TW. Peripapillary retinal nerve fibre layer thickness profile in subjects with myopia measured using the Stratus optical coherence tomography. Br J Ophthalmol. 2010;94(1):115-20.