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Original Article

Evaluation of vascular and neural parameters in amblyopia

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Abstract

Aim: To evaluate the changes of vessel densities and retinal nerve fiber layer thicknesses in strabismic amblyopia.

Materials and Methods: Fifteen cases with unilateral strabismic amblyopia and 20 healthy subjects were enrolled. The vessel densities in the superficial capillary plexus (SCP), deep capillary plexus (DCP), choriocapillary plexus (CCP), foveal avascular zone (FAZ) and foveal vessel density (FD-300) were assessed using OCT-A (AngioVue, RTVue XR Avanti; Optovue, Inc., Fremont, CA). Retinal nerve fiber layer thickness (RNFLT) measurements were evaluated using SS-OCT.

Results: The mean foveal, parafoveal, and perifoveal vessel densities in SCP, DCP, CCP and FAZ area were similar between the amblyopic, fellow and healthy eyes. The RNFLT in all quadrants were higher in amblyopic eyes compared to fellow eyes and controls and the difference was statistically significant in the nasal quadrant ($p<0.001$).

Conclusion: Our results indicate that the vessel densities in retinal vascular plexuses, CCP and FAZ area were similar in amblyopic eyes, fellow eyes and healthy controls. Further large scale studies will be valuable.

Keywords: Optical coherence tomography angiography; retinal nerve fiber layer thickness; strabismic amblyopia

INTRODUCTION

Amblyopia is the leading cause of visual loss in the pediatric population (1). The reduced visual acuity due to strabismus or uncorrected refractive error is associated with deficits in color, motion and contour perception (2). While the ocular examination shows a structurally normal eye, scientific data point toward complex visual cortex, retina and choroid abnormalities (3). Several studies evaluating the pathogenesis of amblyopia have reported structural changes affecting the retina and choroid (4,5).

Optical coherence tomography angiography (OCT-A) permits high-resolution and noninvasive evaluation of the retinal microvascular network. The device provides repeatable assessment of blood flow and density enhances structural vascular information with volumetric angiograms and enables the segmentation at different depths. The vessel densities in the superficial capillary plexus (SCP), deep capillary plexus (DCP), choriocapillary plexus (CCP) and the foveal avascular zone (FAZ) can be easily visualized with OCT-A (6).

This study aimed to describe the OCT-A and retinal nerve fiber layer thickness (RNFLT) changes in eyes with strabismic amblyopia and healthy subjects.

MATERIALS and METHODS

The observational, cross-sectional study was carried out between March 2018 and 2019. Each subject or legal guardian conferred written informed consent. The study was approved by the Institutional Review Board and adhered to the tenets of the Declaration of Helsinki.

Cases with unilateral strabismic amblyopia constituted the amblyopia group. The presence of a visual acuity of less than or equal to 20/30 or a BCVA ≥2 line worse than the fellow eye was classified as amblyopia. The control group consisted of patients who had 20/20 vision without any ocular disorder. Children with anisometropic amblyopia, deprivation amblyopia, other ophthalmic pathologies (e.g., retinal disorder, glaucoma, uveitis etc.), nystagmus, neurological disease, prior ocular surgery or any systemic disease were excluded.

A comprehensive ophthalmologic examination, including best corrected visual acuity (BCVA), biomicroscopy, orthoptic and fundus examination and cycloplegic retinoscopy was performed. Swept-source optical coherence tomography (OCT, Triton, Topcon, Tokyo, Japan) was used to acquire the RNFLT measurements.

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OCT-A measurements were obtained with RTVue-XR Avanti (Angiovue, Optovue, INC, Freemont, CA, USA). This device contains multi scan analysis that enables assessment of three-dimensional images and vascular densities of the superficial and deep capillary plexuses. Split spectrum amplitude decorrelation angiography (SSADA) algorithm produces improved image quality by creating multiple frames. The scan size was 6 × 6 mm frame covering the fovea.

The measurements of the FAZ area, foveal vessel density 300 μ around the FAZ (FD-300) and foveal, parafoveal and perifoveal vascular densities (VD) in the SCP, DCP and choriocapillary (CC) plexus were obtained using the AngioAnalytics software. Automatically segmented images were used to define the retinal layers. The superficial capillary layer was described between the internal limiting membrane (ILM) and inner plexiform layer (IPL), containing the ganglion cell layer. The deep capillary layer comprised the layers between the inner and outer plexiform layers. CC layer contained a 30 µm section located below the RPE. The AngioVue software tool was used to calculate the FAZ area.

Statistical data analysis was done with SPSS software ver. 18 (IBM Corp., Armonk, NY). The categorical variables were compared with the Chi-square or Fisher's exact test. The normality of the variables was assessed using the Kolmogorov-Smirnov test. The OCT-A and RNFLT measurements were compared using the Kruskal-Wallis test or ANOVA. Bonferroni correction was applied for pair-wise comparisons. The statistically significance level was a p value less than 0.05.

RESULTS

Fifteen patients with unilateral strabismic amblyopia with a mean age of 11.2±2.8 years and 20 healthy controls with a mean age of 11.5±3.7 years were enrolled. There was not a significant difference between the groups with respect to age (p=0.76) and gender (p=0.51).

The median cycloplegic refractive spherical equivalent was 2.25 D (range, 1.25 to 4.00 D) in eyes with amblyopia, 1.75 D (range 0 to 4.00D) in the fellow eyes and 0.25 (range -1.00 to 3.00 D) in healthy subjects (p<0.001).

The mean foveal, parafoveal and perifoveal vascular densities in the SCP, DCP, CCP, FAZ area and FD-300 were comparable among the groups (Table 1).

The mean values of central macular thickness in the amblyopic, fellow eyes and control group were 242.2±17.5 µm, 241.1±19.0 µm and 244.6±19.4 µm, respectively. The average, superior, temporal and inferior RNFLT was similar between the groups (Table 2). The mean nasal RNFLT was significantly higher in amblyopic eyes (97.1±17.0 mµ) compared to healthy controls (74.4±16.8 µm) (p=0.001).

Table 1. The comparison of OCTA measurements among the groups

	Amblyopic eyes (n=15)	Fellow eyes (n=15)	Control eyes (n=20)	p
SCP foveal VD	18.5± 6.5	19.8±7.3	19.6± 6.2	0.84*
SCP parafoveal VD	46.7±5.3	47.9±5.9	49.4±3.7	0.30**
SCP perifoveal VD	47.3±3.9	47.3±4.8	48.6±2.2	0.51*
DCP foveal VD	36.1±7.2	38.4±7.4	36.0±7.1	0.56*
DCP parafoveal VD	56.1±3.1	55.9±5.3	53.3±5.0	0.15*
DCP perifoveal VD	50.0±5.6	49.6±5.7	47.1±6.0	0.29*
CCP foveal VD	68.0±7.0	69.2±7.5	72.2±5.3	0.21**
CCP parafoveal VD	68.9±4.2	68.9±2.2	68.8±4.1	0.99*
CCP perifoveal VD	70.5±3.3	71.4±1.9	71.0±3.7	0.74*
FAZ area	0.28±0.1	0.26±0.1	0.27±0.10	0.86*
FD-300	51.4±6.4	51.4±6.3	53.4±5.6	0.56*
CMT	242.2±17.5	241.1±19.0	244.6±19.4	0.85*

*p value: ANOVA test; **p value: Kruskal wallis test
VD: vessel density (%),SCP: superficial capillary plexus, DCP: deep capillary plexus, CCP: choriocapillary plexus, CMT: central macular thickness (µm), FAZ: foveal avascular zone (mm^2)

Table 2. The comparison of RNFLT measurements among the groups

	Amblyopic eyes (n=15)	Fellow eyes (n=15)	Control eyes (n=20)	p
Average RNFLT	116.6±8.2	112.9±8.3	110.7±10.3	0.20
Superior RNFLT	138.4±13.2	136.6±10.8	136.8±12.1	0.92
Inferior RNFLT	149.5±17.0	145.8±14.7	136.3±20.5	0.10
Temporal RNFLT	76.0±11.4	73.6±8.1	72.8±9.6	0.64
Nasal RNFLT	97.1±17.0	86.1±15.2	74.4±16.8	0.001*

RNFLT: retinal nerve fiber layer thickness, (µm).; *p value: ANOVA test

DISCUSSION

Whether amblyopia has any association with the retinal vascular plexuses is important for visual development and amblyopia. OCT-A is a modern imaging technique that allows visualization of the retinal and choroidal network.

Majority of the published studies on OCTA findings in amblyopia included a mix group of cases with strabismic or anisometropic amblyopia. Lonngi et al. (4) and Karabulut et al.(7) have demonstrated that macular superficial and deep retinal capillary vessel densities were significantly reduced in children with amblyopia. Sobral et al. (8) and Chen et al. (5) reported reduced vessel density in SCP but not in DCP. Demirayak et al. (9) found that FAZ and vascular densities in SCP and DCP were similar in cases with amblyopia and healthy controls. Doguizi et al. (10) have studied the OCT-A findings in children with anisometropic amblyopia and demonstrated reduced vessel densities in the superficial and deep retinal vascular plexuses. Unfortunately, this observation could not be replicated in a later study by Kaur et al. (11).

In the present study; the foveal, parafoveal and perifoveal vessel densities in the SCP, DCP in patients with strabismic amblyopia were evaluated. The vessel densities in both retinal plexuses were similar in amblyopic and fellow eyes and healthy controls. Previously, Yilmaz et al. (12) have compared the FAZ and vascular densities of SCP and DCP in amblyopic eyes with fellow eyes and healthy controls. They reported that FAZ was similar between the groups, but the SCP and DCP vascular density values were significantly lower in amblyopic eyes. The results of later studies by Araki et al. (13) and Pujari et al. (14) were in line with our study and showed that vessel densities were similar in eyes with strabismic amblyopia and fellow controls.

The choriocapillary layer in amblyopic patients is evaluated in a limited number of reports. Borrelli et al. (15) have studied the choriocapillaris vessel density in 16 cases with strabismic or anisometropic amblyopia and found that amblyopic eyes had increased choriocapillaris vessel density. On the contrary, Kaur et al. (11) found decreased CCP vessel density in treatment naive cases with anisometropic amblyopia. In the present study, the foveal vessel density in the CCP was lower in eyes with strabismic amblyopia, yet the difference failed to reach to a statistical significance.

The current study described a mean FAZ area of 0.28, 0.26 and 0.27 mm2 in amblyopic, fellow and control eyes. The FAZ area was similar between the study groups. This finding correlated with the outcomes of previous investigators (4,8,9).

The RNFLT in amblyopia has been investigated in several reports previously. The study by Yen et al. (16) revealed an increase in RNFLT in anisometropic amblyopic eyes, but failed to show a significant difference in eyes with strabismic amblyopia. Altıntaş et al. (17), Walker et al. (18) and Lekskul et al. (19) reported similar mean RNFLT measurements in amblyopic and fellow eyes. On the contrary, Kasem and Badawi (20) found that global RNFLT was thicker in amblyopic eyes. In the present study, the RNFLT in all quadrants were higher in amblyopic eyes when compared to fellow eyes and control subjects and the difference was statistically significant in the nasal quadrant. The arrested maturation owing to abnormal stimulus may comply with a thicker nerve fiber layer which have been proposed by previous investigators (16,21).

LIMITATIONS

The limitation of the current study was the relatively small sample size. Secondly, the study group was limited to patients with strabismic amblyopia, thus; our results cannot be reflected to patients with anisometropic or deprivational amblyopia. Also, our patients had mild amblyopia with a visual acuity ranging between 0.1 logMar to 0.3 logMar. The eyes with lower visual acuity may have different results.

CONCLUSION

In conclusion, the vessel densities in retinal vascular plexuses, CCP and FAZ were similar in amblyopic and fellow eyes and healthy controls. The mean nasal RNFLT was found significantly higher in eyes with amblyopia compared to healthy eyes. Prospective studies including different subgroups of amblyopia can be helpful to clarify our results.

Competing Interests: The authors declare that they have no competing interest.
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Ethical Approval: The study was approved by the local ethical committee (protocol number E-19-2468, Ankara Numune Education and Research Hospital).

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