Evaluation of Choroidal thickness in patients with unilateral ambylopia using spectral domain optical coherence tomography (SD-OCT) with quadrant wise analysis

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Research Article

Keywords: Amblyopia, choroidal thickness, subfoveal, anisometropic amblyopia, strabismic amblyopia.

Posted Date: April 13th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1542727/v1

Abstract

Aims and objectives- To determine the choroidal thickness (mainly subfoveal) in the eyes of subjects with anisometropic amblyopia and strabismic amblyopia and to compare the choroidal thickness with that of fellow eyes (control group).

Material and Methods- In this prospective study, 140 eyes of 70 patients were included (age 5-40 years). Each patient underwent a detailed ocular examination which included visual acuity, intra ocular pressure, keratometry, refraction, axial length and choroidal thickness measurement. The choroidal thickness (CT) was measured using enhanced depth imaging (EDI) mode in spectral domain optical coherence tomography (SD-OCT) at subfoveal, o.5 mm, 1mm, 1.5mm in both nasal and temporal quadrants.

Results- The mean sub-foveal CT was 341.73±60.39 µm in amblyopic eyes and 314.77±48.12 µm in control eyes. The CT was significantly thicker in anisometropic amblyopic eyes than fellow eyes (p=0.00), whereas in strabismic amblyopic eyes it was not significantly thicker (p=0.064).

Conclusion- Significant choroidal thickening was observed in subjects with amblyopia, which may contribute to the amblyopia pathogenesis. These changes were more pronounced in patients with anisometropic amblyopia than strabismic amblyopia.

Introduction

Amblyopia is an important public health problem as the visual impairment is life-long.[1] It is defined as reduced best-corrected visual acuity in one or both eyes caused by abnormal visual experience during the development of the visual system without any organic abnormality of the eye.[2] Amblyopic eyes are structurally normal on clinical examination[3] and it is caused by a deprivation of clear vision in the period of neural plasticity early in life.

Causes of visual disability can be presence of strabismus in early life, anisometropia or vision deprivation (e.g. congenital cataract).[2, 4] The above factors are assumed to cause amblyopia by affecting the growth of the cells in the lateral geniculate body and the visual cortex.[5] Recently done studies suggest that the amblyopic eye may have an altered optic nerve, ganglion cells and nerve fiber layer of retina.[6–8] The functioning of choroid has been studied and was found to have an important role in ocular nutrition, temperature control and regulation of volume.[9–11] There is evidence, primarily from research with young animal models [12–14] that the choroid plays an important role in the modulation of refractive state and may be involved in the development of refractive errors.

Active mechanisms are now known to play an important role in achievement of emmetropia that sense blurring of image which involves moving the retina to reduce the blur and permanently altering the ocular dimensions to maintain a clear image. Animal studies have shown that an active increase or decrease in thickness of choroid helps to place the retina at a correct position so as to form a clear image.[15, 16]

Similar changes in choroid of humans have also been seen in response to short-term unilateral image blur.[17, 18] Enhanced depth imaging in optical coherence tomography(OCT) has opened new doors to visualize choroid, thus helping us to do quantitative in vivo assessment that was not possible before.[19]

As no definitive study is present to correlate choroidal thickness in amblyopic eyes in Indian scenario, the present study was aimed to study choroidal thickness in patients with amblyopia in Indian population.

Material And Methods

This prospective observational study consisted of 70 subjects with amblyopia who visited the OPD, at Department of Ophthalmology at a tertiary care centre in northern India. Subjects in whom the chorio-scleral junction could be identified with an image quality of ≥ 6/10 were included. Prior approval from the Institutional Review Board of the institute was taken and informed consent was obtained from each subject. This study was conducted in accordance with the tenets of the Declaration of Helsinki for research involving human subjects.

Inclusion Criterion:

1. Age between 5–40 years, where OCT could be done.
2. Diagnosed strabismic or anisometropic amblyopia.
3. Visual acuity in the amblyopic eye between 20/30 to 20/400; and 20/20 or better vision in fellow eye.
4. No organic eye disease.
5. Patients willing to consent.

Patient with organic eye disease, history or evidence of intraocular surgery, any previous retinal or choroidal pathology, history of ocular trauma and patient not cooperative enough for OCT examination were excluded from the study.

All patients underwent a clinical history taking, complete ophthalmic examination including: visual acuity estimation, subjective and objective refraction, slit lamp examination, IOP estimation by Goldmann applanation tonometery, Keratometry using autorefractometer, axial length measurement using immersion A scan and OCT. OCT scanning was performed using CIRRUS HD-OCT (MODEL 5000, SD-OCT, CARL, ZEISS MEDITEC, INC, USA).

After pharmacological pupillary dilation and instillation of artificial tears, imaging was performed in each subject (both eyes) on the same day. All scans had an image quality factor 60/100 or greater and were taken as close to the fovea as possible.

Choroidal Thickness Measurement

The choroid was visualized by enhanced depth imaging (EDI) technique with spectral domain optical coherence tomography using a standardized scanning protocol. The center of each volumetric

measurement was adjusted to the center of the fovea.

A single line of 6 mm length centered horizontally on the fovea was used for the visualization of the choroid. The vertical distance between the posterior edge of the hyper reflective RPE layer and the chorio-scleral interface was measured manually using the software callipers.

Choroidal thickness was measured subfoveally and 500 microns intervals up to 1500 microns temporal and nasal to the fovea.

Observation And Results

This study included 140 eyes of 70 patients with amblyopia out of which 18 patients (25.7%) had strabismic amblyopia and 52 patients (74.3%) had

anisometropic amblyopia. The other eye of the patients served as control. The

Left eye was the amblyopic eye in 45 patients (64.3%) and right eye was the amblyopic eye in 25 patients (35.7%). Demographic details of the patients are given in Table 1.

Table 1
Age and sex distribution among amblyopic patients

Demographics	Strabismic (n = 18)	Anisometropic (n = 52)	Total	p-value
MALE	9 (50%)	30(60%)	39(55.7%)	
FEMALE	9 (50%)	22(40%)	31(44.3%)	
Age (years) Mean ± SD	19.76 ± 10.83	23.26 ± 11.29	22.5 ± 11.2	0.176

The mean BCVA in the amblyopic eyes was 0.87 ± 0.47 logMAR and 0 ± 0.02 logMAR in control eyes, which was less in amblyopic eyes as compared to control eyes and difference was statistically significant (p = 0.00). Similarly, the mean axial length of amblyopic eyes was 22.26 ± 2.19 mm and 22.78 ± 1.34 mm in control eyes which was lesser in amblyopic eyes as compared to control eyes (p = 0.004).

The mean choroidal thickness 1.5mm temporal to fovea was 247.81 ± 47.18 µm in amblyopic eyes and 244.47 ± 50.74 µm in control eyes which was statistically not significant (p = 0.550). The mean sub-foveal choroidal thickness was 341.73 ± 60.39 µm in amblyopic eyes and 314.77 ± 48.12 µm in control eyes which was significantly thicker in amblyopic eyes (p = 0.000) (Table 2).

Table 2
Comparison of mean temporal (temp) and nasal choroidal thickness among amblyopic eyes and control eyes

	Amblyopic eyes		Control eyes		t	p-value
	Mean	SD	Mean	SD		
TEMP 1.5 mm	247.81	47.18	244.47	50.74	0.600	0.550
TEMP 1mm	280.54	47.91	268.30	48.40	2.153	0.035
TEMP .5 mm	308.61	56.55	288.89	50.28	3.130	0.003
SUBFOVEAL	341.73	60.39	314.77	48.12	3.937	0.000
NASAL.5	312.56	62.89	289.24	47.52	3.367	0.001
NASAL 1MM	285.89	62.68	264.16	43.30	3.121	0.003
NASAL 1.5	254.19	61.08	235.39	45.59	2.766	0.007

The mean sub-foveal choroidal thickness (342.39 ± 49.75 µm; p = 0.06), choroidal thickness at 1.5mm (257.11 ± 44.52 µm; p = 0.6), 1mm (284.06 ± 46.24; p = 0.4) and 0.5mm (308.83 ± 44.69 µm; p = 0.2) temporal to fovea and choroidal thickness at 0.5mm (311.56 ± 45.78 µm, p = 0.219), 1mm (283.72 ± 43.39 µm; p = 0.953) and 1.5mm (246.17 ± 37.43 µm; p = 0.438) nasal to fovea in strabismic amblyopic were found to be statistically non-significant (Table 3).

Table 3
Comparison of mean temporal (temp) and nasal choroidal thickness among strabismic amblyopic eyes and control eyes

Strabismic amblyopia(n = 18)	Amblyopic eyes		Control eyes		t	p-value
	Mean	SD	Mean	SD		
TEMP 1.5MM	257.11	44.52	253.56	50.42	0.418	0.681
TEMP 1MM	284.06	46.24	278.17	51.09	0.711	0.487
TEMP .5	308.83	44.69	298.06	52.48	1.281	0.217
SUBFOVEAL	342.39	49.75	323.17	52.72	1.982	0.064
NASAL.5 mm	311.56	45.78	299.39	51.59	1.277	0.219
NASAL 1mm	283.72	43.39	273.17	50.41	0.953	0.354
NASAL 1.5 mm	246.17	37.43	241.78	50.49	0.438	0.667

The mean choroidal thickness 1.5mm temporal to fovea was 244.60 ± 48.05 µm in anisometropic amblyopic eyes and 241.33 ± 50.96 µm in control eyes which was statistically not significant (p = 0.639). The mean choroidal thickness 1 mm (279.33 ± 48.86 µm; p = 0.04) and 0.5mm (308.54 ± 60.51 µm; p =

0.006) temporal to fovea, sub-foveal choroidal thickness (341.50 ± 64.11 µm; p = 0.001), 0.5mm (312.90 ± 68.20 µm; p = 0.003), 1mm (86.63 ± 68.45 µm; p = 0.004) and 1.5mm (256.96 ± 67.46 µm; p = 0.007) nasal to fovea were significantly more in amblyopic eyes as compared to control eyes (Table 4).

Table 4
Comparison of mean temporal (temp) and nasal choroidal thickness among anisometropic amblyopic eyes and control eyes.

Anisometropic amblyopic(n = 52)	Amblyopic eyes		Control eyes		t	p-value
	Mean	SD	Mean	SD		
TEMP 1.5 mm	244.60	48.05	241.33	50.96	0.471	0.639
TEMP 1 mm	279.33	48.86	264.88	47.47	2.030	0.048
TEMP .5 mm	308.54	60.51	285.71	49.62	2.866	0.006
SUBFOVEAL	341.50	64.11	311.87	46.61	3.446	0.001
NASAL .5 mm	312.90	68.20	285.73	46.04	3.123	0.003
NASAL 1mm	286.63	68.45	261.04	40.64	2.996	0.004
NASAL 1.5mm	256.96	67.46	233.17	44.08	2.830	0.007

Statistical Analysis

At the end of study, data was entered in MS EXCEL spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 25.0.

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± SD and range. Normality of data was tested by Kolmogorov-Smirnov test. If the normality was rejected, then nonparametric test was used.

Quantitative variables were compared using Paired T test/Wilcoxon rank sum test (when the data sets were not normally distributed) across follow up. A p value of < 0.05 was considered statistically significant.

Discussion

Anisometropia begins to be associated with amblyopia when it exceeds the refractive error of fellow eye by approximately 2.5 D. The prevalence and depth of amblyopia is also related to the magnitude of the anisometropia.[20, 21] The prevalence of amblyopia is lower in the children with strabismus when compared to anisometropia.[22] Previous studies have demonstrated that anisometropia can have a major effect on amblyopia because of the decreased resolution caused by optical defocus at the fovea and the production of active suppression.[23, 24]. Till now clinical association of choroidal thickness with

amblyopia remains unknown. Anatomically the foveal avascular zone lacks inner retinal layers and retinal capillaries. This area of the retina is nourished by the choroidal blood vessel. Spaide and colleagues[19] described enhanced depth imaging (EDI) using optical coherence tomography (OCT). This new technique facilitates physicians to measure the thickness of the choroid at various locations within the macular region.[25] Recently OCT has become popular and has allowed clinicians to examine the retinal and choroidal morphology. The main aim of our study was to determine the choroidal thickness (CT) changes in unilateral amblyopia as compared to normal fellow eye. Possibility of choroidal changes in amblyopia has been previously investigated in various studies but the understanding of choroidal changes is incomplete. Few studies regarding choroidal thickness in amblyopic patients have been published.[26–28] In our study the axial length and BCVA of amblyopic and normal fellow was recorded. There was a significant difference in BCVA and axial length of amblyopic eye as compared to normal fellow eye. In our study the difference in subfoveal CT between the amblyopic eyes and the fellow eyes in children with unilateral amblyopia (both in anisometropia and strabismic) was found to be statistically significant (p value < 0.05).

Nishi et al compared choroidal thickness of the amblyopic eyes with fellow eyes and control eyes in a cohort of 25 patients with hyperopic anisometropic amblyopia and found that subfoveal choroid was significantly thicker in the amblyopic eyes as compared to fellow eyes, and control eyes; similar results were also found in our study. [26]

Aygit et al (2015) compared choroidal thickness among 40 eyes of patients having strabismic amblyopia and anisometropic amblyopia with their fellow eyes and 40 control eyes. [27] They found that choroid was significantly thicker in anisometropic amblyopic eyes and also strabismic amblyopic eyes as compared to fellow eyes and the control eyes. In our study, we also found that patients having anisometropic amblyopia had significantly thicker choroid as compared to fellow eyes. But, in case of strabismic amblyopia no statistically significant difference was found. This might be due to unequal patient distribution in our study population. Karaca et al 2017 compared choroidal thickness in 40 eyes having anisometropic amblyopia with fellow eye and also age/sex matched control eyes. [30] They found that subfoveal and nasal choroidal thickness was more in amblyopic eyes as well as in fellow non-amblyopic eyes as compared to healthy eyes. Also temporal choroidal thickness was higher in amblyopic eyes only as compared to normal. Our study indirectly shows same results as this study since we had thicker choroid in amblyopic eyes in subfoveal, nasal as well as temporal quadrants in our anisometropic amblyopic patients.

The strengths of this study are the large numbers of participants and the fact that subfoveal choroidal thickness was measured in addition to 6 other locations. Additionally, this study presented the choroidal thickness of strabismic patients together with the anisometropic patients.

The main limitation of this study was that there was unequal distribution of strabismic and anisometropic amblyopia patients. We did not compare relationship between refractive error and choroidal thickness. Our study cannot answer the cause-effect relationships.

Conclusion

In conclusion, significant choroidal thickening was observed in subjects with amblyopia. These changes were more pronounced in patients with anisometropic amblyopia. Further studies, however, are warranted to conclusively establish the role of choroidal thickness changes and its role in pathogenesis of amblyopia. This is to the best of our knowledge the largest prospective series focussing on the choroidal thickness changes in subjects from India with anisometropic and strabismic amblyopia.

Declarations

Funding:

Nil

Conflict of interest:

Nil

Acknowledgement:

none

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