Original Article

Evaluation of optical coherence tomography changes in amblyopia

Jawahar L Goyal, Jigyasa Arora, Abha Gahlot, Divya Singh, Neharika Sharma, Nisha Yadav[1]

Aim: To study the Central Macular Thickness (CMT) and Retinal nerve fiber layer (RNFL) thickness (RNFLT) using Optical Coherence Tomography (OCT) in cases of amblyopia. **Methods and Material:** The study was conducted on 30 patients of unilateral amblyopia having vision of less than 6/12 (30 amblyopic eyes and 30 fellow eyes) and age matched 30 eyes of normal controls aged between 5-30 years. Vision, Refraction and ophthalmological examination was done. OCT changes in macula and RNFL layer were evaluated in both eyes of each patient and controls. The data was statistically analyzed using SPSS version 22. **Results:** Out of 30 patients 14 were anisomyopic and 16 were anisohyperopics. The mean central macular thickness among amblyopic eyes was significantly increased (238.77±3.64 μm) a.c.t fellow eyes (218.73±4.71μm). Average retinal nerve fibre layer thickness among amblyopic eyes was significantly increased (100.50±7.70 μm) a.c.t fellow eyes (95.67±6.38) (P<0.001). **Conclusions:** The eyes with unilateral anisometropic amblyopia were associated with higher Central Macular Thickness (CMT) and thicker global Retinal Nerve Fibre Layer (RNFL) when compared to normal fellow eyes.

Key words: Amblyopia, anisometropia, OCT

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The concept of amblyopia being caused by a malfunction in the retina has been brought back into discussion, thanks to recent developments in neuroanatomy and neurophysiology. Amblyopia research continues to focus on the retina as a region of interest because of its potential to shed light on the condition. There is still a lot of confusion regarding the retinal change that occurs in amblyopic eyes.[1,2] Amblyopia may interfere with the normal postnatal maturation of retinal ganglion cells (RGCs), which may lead to a decreased number of RGCs as well as abnormalities.[3] Some authors have reported that amblyopic eyes have higher central macular thickness (CMT) and thicker retinal nerve fiber layer (RNFL) compared to fellow eyes,[4-6] while other studies have reported that there is no significant change in CMT and RNFL thickness (RNFLT) in amblyopic eyes.[7-10]

Hence, this case series is aimed to investigate the peripapillary RNFLT and CMT using high-definition optical coherence tomography (HD-OCT) in patients with amblyopia to identify if amblyopia is associated with changes in RNFL and CMT by comparing with fellow eyes. Optical coherence tomography (OCT) is a high-resolution imaging method that does not require any contact with the retina and does not cause any damage to it.[11] There have been a number of investigations into the structural alterations that occur in the macula and RNFL in amblyopic eyes.[10] Because HD-OCT specifically enhances the spatial resolution and scan speed, it is now possible to conduct an in-depth investigation of the retina that includes features as small as 5 μm.

Methodology

In our case series, a total of 30 patients of age between 5 and 30 years with unilateral amblyopia (30 amblyopic eyes and 30 fellow eyes) having visual acuity (VA) less than 6/12 (decimal VA <0.5) were included. The HD-OCT instrument was used to measure the thickness of the macular layer (Cirrus HD-OCT, Model 500; Carl Zeiss Meditec, Inc). Before scanning, the patient's pupils were dilated. The resolution of the scan was between 512 and 128 μm, and it was applied to a cube that is 6 mm on a side and 6 mm in length. Every patient underwent an internal fixation procedure. CMT (also known as foveal thickness) is defined as the average macular thickness in the central 1 mm zone,[5,6] while average macular thickness is defined as the mean of thicknesses in nine regions[6] and macular volume is defined as the sum of volumes in all nine regions. Macular scan was typically of the high-density variety and provides images that are 6 mm wide. The foveola serves as the center of attention for the macular thickness map that measures 6 mm and divides the macula into nine distinct areas.[5] The quantitative evaluation was carried out using the color-coded graph as well as the numerical map. The ring with a diameter of 6 mm was subdivided into three rings: the center ring having a diameter of 1 mm and corresponding to the fovea, the middle ring having a diameter of 2 mm, and the outer ring corresponding to the parafovea (3 mm diameter). RNFLT is evaluated based on a diameter that is 3.4 mm all the way around the optic disc. The software calculates an average thickness for RNFL and measures the mean thickness for each quadrant; it

Department of Ophthalmology, School of Medical Sciences and Research, Sharda University, Greater Noida, U.P., [1]Dr Rajendra Prasad Centre for Ophthalmic Sciences, AIIMS, New Delhi, India

Correspondence to: Dr. Jawahar L Goyal, E-25, Sector 39, Noida - 201 301, U.P., India. E-mail: dr_jlgoyal@rediffmail.com

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also provides an average thickness for RNFL as a whole. The data was subjected to statistical analysis using latest software Statistical Package for the Social Sciences version. Independent paired *t*-test was used for comparison between the two groups.

Results

The mean age of the study participants was 22.67 ± 6.85 years. There were 36.7% females and 63.3% males. CMT, mean macular volume, and RNFLT between amblyopic and non-amblyopic eyes are compared in Table 1 and were found to be significantly increased in amblyopic eyes.

In the myopic anisometropic group, the mean best corrected visual acuity (BCVA) was lower (0.28 ± 11) in amblyopic eyes when compared to the fellow eyes (0.92 ± 0.16) (*P* value 0.15). Similarly, among those in the hyperopic anisometropic group, mean BCVA was lower (0.24 ± 0.10) in amblyopic eyes when compared to the fellow eyes (0.92 ± 0.16) (*P* value 0.34). The mean spherical equivalent in myopic amblyopic eye was –5.054 ± 2.02 and in hyperopic amblyopic eye was +3.92 ± 1.36. Comparison of CMT and RNFLT in all four quadrants in the myopic and hyperopic groups between amblyopic and non-amblyopic eyes is presented in Table 2. A comparison among various studies is presented in Table 3.

Table 1: Distribution of CMT and RNFLT between amblyopic and fellow eyes among the study participants

Parameters	Amblyopic eye (*n*=30)	Fellow eye (*n*=30)	*P*
CMT, μm	238.77±3.64	218.73±4.71	0.001*
Macular volume, mm^3	10.14±0.45	9.86±0.35	<0.001*
RNFLT, μm			
Superior	120.20±8.51	116.43±7.26	0.13
Inferior	126.47±10.58	122.63±8.99	0.02*
Temporal	76.47±9.75	71.53±8.54	0.01*
Nasal	67.87±6.32	62.47±5.32	<0.001*
Average	100.50±7.70	95.67±6.38	<0.001*

*Statistically significant. CMT=central macular thickness, RNFLT=retinal nerve fiber layer thickness

Table 2: OCT parameters between amblyopic eyes and fellow eyes comparing myopic and hyperopic groups

Parameters	Amblyopic eye	Fellow eye	*P*
CMT, μm			
Myopic	237.29±20.74	214.43±26.76	0.07
Hyperopic	240.06±16.72	222.50±25.13	0.005*
RNFLT, μm (superior)			
Myopic	120.43±9.37	116.71±7.73	0.04*
Hyperopic	120.00±7.97	116.19±7.08	0.03*
RNFLT, μm (inferior)			
Myopic	126.64±11.39	122.36±9.46	0.012*
Hyperopic	126.31±10.21	122.87±8.68	0.01*
RNFLT, μm (nasal)			
Myopic	74.36±8.68	70.00±6.05	0.001*
Hyperopic	78.31±10.52	72.87±10.26	0.03*
RNFLT, μm (temporal)			
Myopic	65.93±5.06	61.50±4.38	0.006*
Hyperopic	69.56±6.96	63.31±0.05	0.02*
RNFLT, μm (average)			
Myopic	102.64±7.35	97.14±6.16	0.001*
Hyperopic	98.63±7.74	94.38±6.47	<0.001*

*Statistically significant. CMT=central macular thickness, OCT=optical coherence tomography, RNFLT=retinal nerve fiber layer thickness

Discussion

Amblyopia is a disorder that is recognized for manifesting itself throughout the period of development and maturation of the visual pathway that runs between the retina and the central neurons. As imaging technology has advanced, there has been a resurgence of interest in the study of the changes in the structure of the retina in amblyopia.

In our study, a total of 30 patients of unilateral anisometropic amblyopia were included. The mean age of the study participants was 22.67 ± 6.85 years, which was older than that reported by Kasem and Badawi,[5] where a total of 64 patients with age ranging between 7 and 32 years and with a mean age of 13.3 ± 3.7 years were included.

In the case series, there was a significant increase in macular thickness (*P* = 0.001) in amblyopic eyes compared to fellow eyes (238.77 ± 3.64 vs. 218.73 ± 4.71 μm, *P* < 0.001) [Table 1], which is consistent with the findings of Kasem and Badawi,[5] where mean CMT was 196.2 ± 50.03 μm in the amblyopic eyes and 167 ± 12.76 μm in the fellow eyes (*P* = 0.000) and the mean macular volume was 7.59 ± 0.32 mm^3 in the amblyopic eyes and 7.34 ± 0.071 mm^3 in the fellow eyes (*P* = 0.002). In the Sydney Childhood Eye Study, Huynh *et al.*[4] tested 53 amblyopes with either strabismus or hyperopic anisometropia and reported that amblyopic eyes had greater macular thickness than the normal fellow eyes. This was consistent with our findings.

In our series, the hypermetropic amblyopic eyes were found to have a thicker CMT [Table 2] and a higher macular volume [Table 1] than the fellow eyes. This is consistent with the findings of Yoon *et al.*,[10] who studied 31 hyperopic anisometropic amblyopes and reported significant increase in macular thickness between the amblyopic and normal fellow eyes. However, Wang and Taranath[12] and Yakar *et al.*[13] reported that the difference in the macular thickness between the hypermetropic amblyopic and normal eyes was negligible. Dickmann *et al.*[14] also measured 20 mixed anisometropic amblyopes (10 with myopic anisometropia and 10 with hyperopic anisometropia) and reported no significant difference in macular thickness. However, they did not separate myopic from hyperopic anisometropic amblyopia or reported the macular thickness in each group separately as done in our series.

However, the outcome in myopic eyes was found to have a nonsignificant difference in CMT compared to the normal fellow eyes in our series, which was in contrast with the findings of Pang *et al.*,[15] who reported significantly greater CMT in the myopic amblyopic eyes compared to the normal fellow eyes. Earlier authors have reported that myopia, particularly in mild degrees, has a negligible effect on the thickness of the macula.[16,17]

In our series, there was significant increase in global RNFLT (*P* < 0.001) between amblyopic eyes and the fellow eyes [Table 1]. The same higher values for RNFLT were

Table 3: Comparative study between amblyopic and fellow eyes on the basis of RNFL and central macular thickness

Author	Study design	Sample size	RNFL thickness (amblyopic eye vs. normal eye)	Macular thickness (amblyopic eye vs. normal eye)
Alotaibi *et al*.[18] (2011)	Cross-sectional study	93	Increased (112.16 vs. 106 µm)	No change (259.3 vs. 255.6 µm)
Manal Ali Kasem *et al*.[5] (2017)	Cross-sectional study	64	Increased (97.00±11.60 vs. 78.50±13.05 µm)	Increased (196.2±50.03 vs. 167±12.76 µm)
Hadad *et al*.[20] (2011)	Prospective institutional study	45	No change (95.4 vs. 94.0 µm)	Increased (273.8 vs. 257.9 µm)
Celik *et al*.[19] (2015)	Prospective study	43	No change (P>0.05)	No change (P>0.05)
Lekskul *et al*.[8] (2018)	Cross-sectional study	26	No change (95.87±14.56 vs. 97.87±14.56 µm)	No change (270.87±14.43 vs. 275.60±14.43 µm)
Alhamami *et al*.[22] (2020)	Case–control study	30	_	Anisometropic amblyopia- superior and inferior RNFL thinning Strabismic- inferior RNFL thinning
Parikh *et al*.[21] (2022)	Cross-sectional study	91	No change (P=0.5)	No change (P=0.38)
Pang *et al*.[15] (2011)	Cross-sectional study	31	_	Thicker fovea and thinner inner and outer macula in the amblyopic eye
Yoon *et al*.[11] (2005)	Prospective study	31	Increased (115.2 vs. 109.6 µm)	No change (252.5 vs. 249.7 µm)
Dickmann *et al*.[14] (2009)	Cross-sectional study	40	No change	Increased (267 vs. 253 µm, P=0.005)
Huynh *et al*.[4] (2009)	Cross-sectional study	4118 school children	No change	Increased, but not statistically significant
Wu *et al*.[23] (2013)	Prospective cohort study	72	Increased (113.9±7.2 vs. 109.2±6.9 µm)	No change, but the mean macular foveola thickness was more in amblyopic eyes

RNFL = retinal nerve fiber layer

found in hypermetropic and myopic amblyopic eyes, with a significant difference observed from the normal eyes [Table 2]. This was consistent with the findings of Kasem and Badawi,[5] who reported that the mean global RNFLT was 97.00 ± 11.60 µm in the amblyopic eyes and 78.50 ± 13.05 µm in the fellow eyes (P = 0.029), and Alotaibi and Al Enazi,[18] who reported that amblyopic eyes had a substantially thicker RNFL (P = 0.0001). However, others found no significant differences in RNFLT of amblyopic eyes compared to normal fellow eyes.[8,12,14,19-21]

Still, it is not clear as to how the CMT, macular volume, and RNFLT are increased in amblyopia eye compared to fellow eye or normal control eye. In addition, since it is a case series, no pre- and post-therapy data is available to compare the results with, and hence, further reports are required to know whether there are any changes in macular thickness, macular volume, or RNFLT after amblyopia is treated with occlusion therapy. Although we could not perform electrophysiologic studies like Pattern visual evoked potential (VEP) and Pattern electroretinogram (ERG) because of lack of facilities, it is worthwhile to recommend these case series in amblyopic eyes before and after occlusion therapy to know the changes in the functional status of the macula. Few limitations of our series like small sample size and inclusion of solely anisometropic amblyopic patients need to be addressed in further studies, and it will be worthwhile to include other categories of amblyopia, for example, deprivation amblyopia, strabismic amblyopia, and meridional amblyopia, to confirm the changes in CMT and RNFLT in amblyopic eyes in future.

Learning highlights from the case series

Eyes with unilateral amblyopia had higher CMT and thicker global RNFLT when compared to the normal fellow eyes. Anisohyperopic amblyopic eye showed significant increase in both CMT and RNFLT when compared to the fellow eye. However, anisomyopic amblyopic eye did not show any increase in CMT, but RNFLT was significantly increased when compared to the fellow eye.

Conclusion

The eyes with unilateral amblyopia had higher Central Macular Thickness (CMT) and thicker global Retinal Nerve Fibre Layer (RNFL) when compared to the normal fellow eyes. The anisohyperopic amblyopic eye showed significant increase in both CMT and RNFLT when compared with fellow eye. However, anisomyopic amblyopic eye didn't show any increase in CMT but RNFLT was significantly increased when compared to fellow eye. However, further studies with more number of subjects are needed to confirm the changes in the CMT and RNFLT in amblyopic eyes.

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Conflicts of interest: There are no conflicts of interest.

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