Original Research Article

OCT Macular Changes in Amblyopic Children

Abstract

Background: Amblyopia is defined as a decrease in best-corrected visual acuity in one or both eyes that is not solely due to a defect in the structure of the eye. This study aimed to investigate the OCT changes occurring in the amblyopic eye retina compared to the normal eye.

Methods: This prospective study was carried out on 30 cases diagnosed with amblyopia using the better eye as a control. Patients were subjected to Assessment (visual acuity was measured by Landolt's chart, refraction error measured by auto refractometer), and macular analysis.

Results: CMT was a statistically insignificant difference between amblyopic and non-amblyopic eyes. The difference in AMT between amblyopic and non-amblyopic eyes was statistically significant (p = 0.001). BCVA in different ages before and after treatment was a statistically significant difference (P=0.001). The various types of refractive errors of the studied eyes regarding BCVA before and after treatment were statistically significant (P=0.001).

Conclusions: CMT and AMT of the amblyopic eye more than the sound eye, and after 6 months of patching, there was a decrease in the CMT and AMT of the amblyopic eye.

Keywords: OCT, Macular Changes, Amblyopic Children.

Introduction

Amblyopia is defined as a decrease in best-corrected visual acuity in one or both eyes that is not solely due to a defect in the eye structure. The prevalence of amblyopia worldwide is approximately 1%-5%. Amblyopia may be bilateral, and this is called isoametropic amblyopia or unilateral commonly in hyperopia and astigmatism and less common in myopia. Amblyopia is a condition in which the normal development of the cortical visual pathway is disrupted during childhood. It is defined as a discrepancy of two or more lines in best-corrected visual acuity between the eyes clinically [1].

Amblyopia lowers visual acuity and contrast sensitivity due to unusual visual processing in the primary visual cortex (V1). Amblyopia can be caused by a variety of ocular disorders, including uncorrected refractive problems, strabismus, and obstruction of the central visual axis. During the "critical time" of brain plasticity, amblyopia is treated by addressing the underlying cause and penalising the healthy eye. Treatment was traditionally suggested for children until they were 8–9 years old. Recent research suggests, nevertheless, that therapy of older people may be successful since the visual system's plasticity may stretch into adulthood. Furthermore, in children and adults with amblyopia, medication that addresses inhibitory interactions within the visual cortex may enhance both binocular and monocular visual performance [2]. Amblyopia can be caused by uncorrected refractive defects, strabismus, visual axis obstruction, or an integration of these factors [3]. The evidence for amblyopic retinal changes is still inconclusive and debatable. In the amblyopic eye, retinal ganglion cells are disturbed, which results in greater thickness of the retinal nerve fiber layer (RNFL). Disruption of the macula's physiological development, such as the relocation of Henle's fibers away from the foveola, and a decline in foveal cone diameter, were also believed to cause an increase in foveal thickness [4]. Previous investigations of the retina utilizing optical coherence tomography (OCT) imaging have yielded contradictory findings.

In amblyopia, researchers began to measure the thickness of the fovea's layers. Till now, the studies have produced contradictory findings. They discovered that in anisohypermetropic amblyopic eyes, the length of the outer segment (OS) layer of a photoreceptor in the fovea was substantially thinner than in companion eyes [6]. They also noticed reduced length in foveal cones and a thicker overall fovea in amblyopia eyes [7]. In both the inner plexiform and ganglion cell layers, they discovered a significant difference between amblyopic and fellow eyes but not in the outer segment layer [8].

The eyes of amblyopic and non-amblyopic showed an insignificant difference; however, there was a substantial difference between amblyopic and control eyes [9]. These inconsistencies could be related to differences in ethnicity, patient age, amblyopia severity, or assessment procedures for foveal layer thickness [10]. Therefore, the goal of this investigation was to make a comparison in the OCT alterations in the retina of an amblyopic eye to a normal eye and measure each retinal layer thickness in various parts of the fovea (within a 0.5mm radius of the foveal center) in the children eyes diagnosed with unilateral amblyopia with those from the age-matched control eyes.

Patients and Methods

This prospective study was conducted on 30 cases diagnosed with amblyopia using the better eye as a control, age 4-6 years, and the difference in best-corrected visual acuity of 2 or more lines between the eyes. All participants signed an informed consent form. The Research Ethical Committee of Tanta University's Faculty of Medicine approved this study.

Children with sensory lesions as: (Congenital cataract - Corneal opacity), previous squint surgery, uncooperative patient: (young age and mentally retarded), previous surgical intervention, and previous amblyopia treatment were excluded.

Methods: Assessment (Landolt’s chart measured visual acuity. Refraction error measured by auto refractometer using cycloplegic refraction test. Cycloplegia induced by instillation of

cyclopentolate 1% eye drops. Detailed ophthalmologic and fundoscopic examination by slit-lamp biomicroscopy. Patching the sound eye of children 4-6 years according to the severity of amblyopia if mild 2 hours per day and if severe 6 hours per day for 1 month and follow up for 6 months by OCT. SD-OCT will measure the macular thickness. The Spectral domain optical coherence Tomography CIRRUS™ (Cirrus-4000 OCT, ZEISS corporation, Carl-Zeiss, Germany) was used to measure the macular thickness. CIRRUS™ normative databases matched the average anatomic age and ethnical diversity values and obtained clearance from the US food and drug administration (FDA)).

Macular analysis: The print shows a line scanning ophthalmoscope (LSO) fundus image with an ILM-RPE retinal thickness map overlay. With Fovea Finder, the ETDRS grid is automatically centered on the fovea. The retinal thickness values, measured in microns from the ILM to the RPE, are compared to normative data. Slice navigator allows you to see a selected point on an LSO picture, an OCT fundus image, a retinal thickness map, layer maps, and an OCT image all at the same time. The Fovea Finder allows for exact ETDRS grid placement. The macular thickness map is a topographical numerical and colored coded depiction of retinal thickness. Chart format expressed showing central subfield thickness (ILM-RPE thickness), average macular thickness, and volume. The average thickness of all spots along the calculation circle is displayed for both eyes. Each quadrant's average thickness is also displayed. The patient's data is compared to normative data in each of these charts. Symmetry is highlighted in the data table, which is also compared to normative data.

Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). The mean and standard deviation (SD) of quantitative values were reported. Qualitative variables were presented as frequency and percentage (%). A P value ≤ 0.05 was used to determine statistical significance.

Results

Error! Reference source not found. showed gender and age distribution of patients and Subdivision of studied eyes as regard refraction

Table 1: Gender and age distribution of patients and Subdivision of studied eyes as regard refraction (n=30)

Gender	**Male**	6(20.0%)
	Female	24(80.0%)
	Total	30(100.0%)
Age	**4 years**	5(16.7%)
	5 years	9(30%)
	6 years	16(53.3
	Total	30(100.0%)
Refractive error	**Myope**	9(30%)
	Hypermetrope	6(20%)
	Strabismus	4(13.3%)
	Hypermetropic astigmatism	11(36.7%)
	Total	30(100%)

Data are represented by number (%)

BCVA in different ages of our patients (4, 5, 6 y) before and after treatment was statistically significant difference (P=0.001). The different types of refractive errors of the studied eyes regarding BCVA, before and after treatment was statistically significant diffrence(P=0.001). (**Error! Reference source not found.**)

Table 2: The mean values of (BCVA) in different age groups and in studied eyes with different refractive errors

		Range (BCVA) logMAR			**Mean**	**±**	**S. D**	**t. test**	**p. value**
4 Years	**Before**	1	–	1.2	1.08	±	0.11	20.246	**0.001***
	After	0.2	–	0.2	0.20	±	0.00		
5 Years	**Before**	1	–	1.2	1.13	±	0.10	17.964	**0.001***
	After	0.3	–	0.5	0.32	±	0.07		

6 Years	**Before**	0.8	–	1.2	0.98	±	0.16	10.641	**0.001***
	After	0.3	–	0.5	0.40	±	0.10		
Myope	**Before**	0.8	–	1.2	1.00	±	0.17	12.203	**0.001***
	After	0.2	–	0.3	0.27	±	0.05		
Hypermetrope	**Before**	0.8	–	1.2	1.00	±	0.18	10.413	**0.001***
	After	0.2	–	0.3	0.28	±	0.04		
Hypermetropic astigmatism	**Before**	0.8	–	1.2	1.02	±	0.17	9.961	**0.001***
	After	0.3	–	0.5	0.45	±	0.09		
Strabismus	**Before**	1	–	1.2	1.10	±	0.12	5.563	**0.001***
	After	0.5	–	0.8	0.63	±	0.13		

*: Statistically significant at $p \leq 0.05$, BCVA, Best Corrected Visual Acuity

CMT was a statistically insignificant difference between amblyopic and non-amblyopic eyes. AMT was a statistically significant difference between amblyopic and non-amblyopic eyes (p value= 0.001). (**Error! Reference source not found.**)

Table 3: CMT and AMT evaluation of studied amblyopic and non-amblyopic eyes

	Amblyopic eye	**Non-amblyopic eye**	**T. test**	**P. value**
CMT	219 – 270	209 – 264	1.320	0.192
	237.7 ± 18.63	231.4 ± 18.35		
AMT	270 – 305	249 – 292	3.426	**0.001***
	286.1 ± 10.61	275.4 ± 13.42		
Part time occlusion (PTO)	2 – 6	5.07 ± 1.72		

*: Statistically significant at $p \leq 0.05$, Data are represented by range or mean± SD, CMT: Central Macular Thickness, AMT: Average Macular Thickness

CMT was a statistically insignificant difference in amblyopic eyes before and after patching. AMT was a statistically significant difference in amblyopic eyes before and after patching (p value= 0.004). (**Error! Reference source not found.**)

Table 4: CMT and AMT evaluation of studied amblyopic eyes before and after patching

	Before	**After**	**T. test**	**P. value**
CMT	209 – 270	210 – 268	1.405	0.163
	234.55 ± 18.60	229.70 ± 19.20		
AMT	249 – 305	212 – 291	2.921	**0.004***
	280.75 ± 13.15	272.30 ± 18.14		

*: Statistically significant at $p \leq 0.05$, CMT: Central Macular Thickness, AMT: Average Macular Thickness

As regards best-corrected visual acuity (BCVA) of the amblyopic eye, BCVA was evaluated before patching, every month till 6 months after patching, and the results were statistically significant (p value= 0.001) (**Error! Reference source not found.**)

Table 5: Follow up of BCVA of amblyopic eyes

BCVA of an amblyopic eye (log MAR)		**1.2**	**1**	**0.8**	**0.6**	**0.5**	**0.3**	**0.2**	**Total**	**X^2**	**P-value**
Before	**N**	11	11	8	0	0	0	0	30	205.051	**0.001***
	%	36.7 %	36.7 %	26.7 %	0.0%	0.0%	0.0%	0.0%	100.0 %		
1 month	**N**	4	15	9	2	0	0	0	30		
	%	13.3 %	50.0 %	30.0 %	6.7%	0.0%	0.0%	0.0%	100.0 %		
2 months	**N**	0	13	4	10	3	0	0	30		
	%	0.0%	43.3 %	13.3 %	33.3 %	10.0 %	.0%	.0%	100.0 %		

3 months	**N**	0	12	4	9	4	1	0	30		
	%	0.0%	40.0 %	13.3 %	30.0 %	13.3 %	3.3%	.0%	100.0 %		
4 months	**N**	0	2	3	8	11	6	0	30		
	%	0.0%	6.7%	10.0 %	26.7 %	36.7 %	20.0 %	.0%	100.0 %		
5 months	**N**	0	0	2	5	13	9	1	30		
	%	0.0%	.0%0	6.7%	16.7 %	43.3 %	30.0 %	3.3%	100.0 %		
6 months	**N**	0	0	1	2	9	14	4	30		
	%	0.0%	.0%	3.3%	6.7%	30.0 %	46.7 %	13.3 %	100.0 %		

Discussion

Amblyopia is treated mostly by occluding the superior eye with an opaque patch to improve vision. Two to six hours of partial occlusion each day is demonstrated to produce similar results as full-time occlusion when used as directed. One to two hours of maintenance patching every day is recommended frequently to inhibit amblyopia from recurring following patching with success because the length of the patch-on and patch-off intervals should be proportional to the severity of amblyopia [12].

As regard refractive error with the mean BCVA , our study included 9 myopes (1.00 ± 0.17), 6 hypermetrope (1.00 ± 0.18), 4 strabismus (1.02 ± 0.17) ,and 11 hypermetropia astigmatism (1.10 ± 0.12)whereas Yoon and Chun [13] showed unilateral anisometropic amblyopia; 10 hyperopia (3.5 ± 2.1) and 12 myopia (2.2 ± 1.9) as the remaining patients missed in follow up, EID et al., [12] revealed 26 Myopia (-7.07±4.55) and 14 Hypermetropia (3.93±1.96), moreover, Liu et al., [14] illustrated 20 anisometropic, 12 strabismic anisometropic, 5 strabismic amblyopia and 7 ametropic amblyopia but Kavitha et al., [15] included Unilateral

anisometropic amblyopia 7 myopia, 5 hypermetropia and18 astigmatism (Mean =0.63±0.405 for all types).

In our study, The duration of part-time occlusion varied from 2 – 6 hours per day for a month according to the severity of amblyopia with the mean value was 5.07 ± 1.72; if mild, 2hours per day and if severe 6 hours per day and follow up for 6 months. In Yoon and Chun [13]study PTO was 6 to 8 hours of partial occlusion for 11.6 ± 2.3 months, whereas Kavitha et al., [15] study revealed occlusion therapy at the first visit (baseline) and every 3 months for one year.

On comparison amblyopic eyes with non-amblyopic eyes as regard CMT in our study, the mean values were 237.7 ± 18.63 and 231.4 ± 18.35 respectively that was statistically insignificant (p value=0.192), whereas on comparison as regard AMT, the mean values were 286.1 ± 10.61 and 275.4 ± 13.42 respectively that was statistically significant. In Liu et al., [14] study, between amblyopic and normal fellow eyes, no significant differences were detected in macular volume, or choroidal thickness, macular thickness.

In Kavitha et al., [15] investigation, in children with anisometropic amblyopia, the MT was more in amblyopic eyes (286.9 ± 6.52 µm) in comparison with non-amblyopic fellow eyes (240 ± 10.45 µm) and normal children with normal eyes (239.8 ± 4.294 µm).

Pang et al., [16] studied children with an average age of 9.56 years and found that the amblyopic eye has a narrower inner and outer macula than the normal eye in amblyopic children with severe unilateral myopia. These results suggest that anatomic changes in the retinas of amblyopic children with unilateral high myopia are possible.

Dickmann et al., [17] studied OCT to measure macular thickness in 20 strabismic amblyopes, and it was discovered that the macular thickness in the amblyopic eye was more significant than in the normal fellow eye in patients with strabismic amblyopia.

Kavitha et al. [15] reported that MT in amblyopic eyes was higher than normal eyes, and it reduced when BCVA improved after occlusion therapy.

Our study regarding CMT of studied eyes showed that the mean was 234.55 ± 18.60 before patching and 229.70 ± 19.20 after patching, which was statistically insignificant. In contrast, the mean AMT was 280.75 ± 13.15 before patching and was 272.30 ± 18.14 after patching, which was statistically significant. Contrary to our study, in Eid et al., [12] study, the mean CMT was 188.30 ± 28.33 before patching and was 195.08 ± 33.88 after patching, which was statistically significant. Still, the mean AMT was 267.65 ± 20.60 before patching and was 268.40±21.28 after patching, which was statistically insignificant.

Liu et al. [14] found that the recovered amblyopic eyes' corrected macular and choroidal biometric values were not substantially different from the persistent amblyopic eyes'.

Yoon and Chun, [13] , before to and after occlusion therapy, found no statistical difference in the thickness of the inferior, superior, temporal, and nasal quadrants in the inner (3 mm diameter) and outer (6 mm diameter) macula of individuals with unilateral anisometropic amblyopia. None of these measures were significantly changed after occlusion therapy.

Kavitha et al., [15] observed a statistically significant decrease in MT on each visit (5= 251.40 ± 12.51) compared to baseline (288.20 ± 6.62) [visit 1] however, in amblyopic eyes after occlusion therapy, there was no statistically significant difference in RNFLT.

Pang et al., [16] documented that before amblyopia treatment, the peripheral maculae of amblyopic eyes in children with myopic anisometropia were thinner than those of the other eyes. Following treatment for amblyopia, central maculae became thinner, but peripheral maculae remained the same.

In our study, BCVA was evaluated before patching, every month till 6 months after patching and the results were statistically significant (p value= 0.001).

In Eid et al., [12] study regarding BCVA, they noted a statistically significant difference when compared pre – (0.27 ± 0.12) and post-amblyopia treatment (0.49 ± 0.20).

Liu et al., [14] found the type of amblyopia (strabismic anisometropic amblyopia) and the initial severity of the amblyopia (BCVA ≤ 0.3) were risk factors for persistent amblyopia in 47 – 96.3% of amblyopic people.

Kavitha et al., [15] observed the effects of occlusion therapy on BCVA after three, six, nine, and twelve months. They discovered an enhancement in BCVA across all patients after one year of occlusion therapy.

Conclusions

The amblyopic eye has more CMT and AMT than the healthy eye, and after 6 months of patching, there was a decrease in the CMT and AMT of the amblyopic eye.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly used in our research area and country. There is no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for litigation but the advancement of knowledge. Also, the research was not funded by the producing company rather, it was funded by personal efforts of the authors.

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