Evaluation of Nerve Fiber Layer Thickness & Ganglion Cell Complex in Amblyopia

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Abstract: Amblyopia is the most frequent cause of unilateral poor visual acuity (VA) in children, with an incidence of 0.5- 3.5% in preschool and school-age children. Amblyopia develops in children up to the age of 6-8 years and persists life-long. Preschool vision screenings have aimed to provide a safety net by identifying children with risk factors for amblyopia while they are still within the critical period of treatment efficacy. This is followed by occlusion or penalisation of the dominant eye that aims to enhance cortical processing of visual input from the amblyopic eye by temporarily limiting cortical input from the dominant eye. Enoch et al. were the first of many authors to suggest a specific cause for an organic anomaly affecting the retina in amblyopia. OCT was a fast, noninvasive, noncontact, transpupillary ophthalmic imaging technique that made measuring of retinal, macular nerve fiber layer and other ocular structures thicknesses. SD-OCT allows for higher resolutions, improved visualization of retinal morphology and retinal pathology, and faster scanning times. This study used SD-OCT to compare retinal nerve fiber layer (RNFL) thickness and ganglion cell complex (GCC) in amblyopic and fellow eyes of patients of varied ages. Twenty patients (10 patients with Anisometropic amblyopic and10 patients with Strabismic amblyopic) with unilateral amblyopia, underwent SD- OCT examination for both amblyopic and follow eyes. The study showed there was no significant different in RNFL between amblyopic and fellow eyes in two groups of anisometropic and strabismic amblyopia. Regarding GCC thickness, there was a statistically significant difference between Amblyopic eyes and fellow eyes within the Strabismic group of patients regarding means of Superior GCC thickness measurements. Also, There was a statistically significant difference between Amblyopic eyes and fellow eyes within the Anisometropic group of patients regarding means of Inferior GCC thickness measurements. There were no statistically significant differences between the Amblyopic eyes of two groups of patients regarding means of RNFL and GCC thickness. For fellow eyes between the two groups, there was a statistically significant difference between the two groups of patients regarding means of Average RNFL thickness in fellow eyes and means of Inferior RNFL thickness in fellow eyes. There is a Statistically Significant moderate positive correlation between BCVA of Amblyopic eye and GCC thickness measurements within the Anisometropic groups of patients.

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1. Introduction

Amblyopia is a developmental defect of the brains visual pathway; it is the most frequent cause of unilateral poor visual acuity (VA) in children, with an incidence of 0.5- 3.5% in preschool and school-age children. Amblyopia develops gradually due to vision deprivation and/or abnormal binocular interaction, with absence of pathological conditions of the eye or the visual pathway in the brain, and usually presents itself in children within the age of 6-8 years and persists life-long **(Andalib et al., 2013)**.

Etiology of Amblyopia includes - but is not limited to:

***1.* Refractive Amblyopia**

Uncorrected refractive errors are considered the most common cause of amblyopia.

A. **Anisometropic amblyopia** is caused by a difference in refractive error between the two eyes which may be as little as 1.0 D sphere. The more ametropic eye receives a blurred image, in a mild form of visual deprivation. It is frequently associated with micro-strabismus and may coexist with strabismic amblyopia (**Hess, 2001**).

B. **Isoametropic amblyopia** occurs when both eyes are amblyopic from a significant yet similar refractive error (**Hess 2001**).

C. Meridional amblyopia Amblyopia caused by significant astigmatism (**Hess 2001**).

***2.* Strabismic amblyopia** results from abnormal binocular interaction where there is continued monocular suppression of the deviating eye (**Hess 2001**).

***3.* Deprivation amblyopia**

Deprivation amblyopia is the least common and typically most severe form of amblyopia and develops when the visual axis is obstructed. Various causes of stimulus deprivation include eyelid ptosis, cornea opacities, cataracts, vitreous hemorrhage among others (**Hess 2001**).

Reverse Amblyopia

Reverse amblyopia is a result of penalization of the sound eye with patching or atropine during amblyopia treatment of the original amblyopic eye. The type of amblyopia and its severity not only adversely affect visual acuity but also binocularity, contrast sensitivity, grating acuity, and central versus eccentric fixation (**Hess 2001**).

The Mechanism of development of amblyopia involves affecting various levels of the visual pathway. It has been reported that shrinkage of cells in the lateral geniculate nucleus that receive input from the amblyopic eye and a shift in the dominance pattern in the visual cortex could be one of those effects (**Huynh et al., 2009**).

However, some other pathological mechanisms are still considered to be controversial such as involvement of the retina**. (Huynh et al., 2009, Kanski 2011, Kasem and Badawi (2017)**

This controversy persists till our current day especially after modern advances in neuro-anatomy and neuro-physiology have reopened the possibility that there is some retinal dysfunction in amblyopia **(Von Noorden and Crawford 1992).**

Optical coherence tomography (OCT) is a non-invasive test in which the thickness of the retinal nerve fibre layer (RNFL) is measured **(Yen et al., 2004)**.

According to a study conducted in 2017, it was concluded by using OCT that the unilateral amblyopic eyes had thicker RNFL compared to un amblyopic eyes. Retinal variations between different types of the amblyopia differ from one type to another. Also, it was concluded that age of study subjects may alter prognosis and treatment of the condition. Despite being conducted very recently, the study researchers recommended emphasizing those conclusions by conducting further studies (**Kasem and Badawi 2017**).

Therefore, in this study OCT will be used to compare retinal nerve fibre layer (RNFL) thickness and ganglion cell complex (GCC) inamblyopic and fellow eyes of patients of varied ages.

Aim of the Study

To compare retinal nerve fibre layer (RNFL) thickness and ganglion cell complex (GCC) in amblyopic and fellow eyes of patients of varied ages using Optical Coherence Tomography (OCT).

2. Patients and Methods

Study Design: cross-sectional study was conducted.

Population of study

A prospective observational clinical study on 20 patients with unilateral amblyopia (Strabismic or anisometropic amblyopia). OCT examination was done for both amblyopic and soud eyes.

The patients were divided into 2 groups:

- Group A: 10 patients with anisometropic amblyopia.
- Group B: 10 patients with Strabismic amblyopia.

The patients were selected from those attending the outpatient clinics of the ophthalmology department in National institute of Diabetes and Endocrinology, Cairo, Egypt, where examinations and imaging also took place.

Inclusion criteria

- Patient with Strabismic or anisometropic amblyopia only.
- The VA difference between the amblyopic and normal eyes was at least 2 lines of Snellen acuity.

Exclusion criteria:

- Previous intraocular surgery
- Any intraocular pathology

(History of cataract, glaucoma, retinal disorders, or laser treatment)

Methods:

All patients had undergone a detailed eye examination including:

- Anterior segment examination using Slit-lamp to excludeanterior segment abnormalities or media opacity.
- Cycloplegic refraction
- Visual acuity: Uncorrected VA (UCVA) & best corrected VA (BCVA) using snellen charts.
- Cover–uncover test to determine strabismic type:
- Prism cover test measures the angle of deviation in strabismic patients
- Intraocular pressure (IOP) measurement by applanation tonometry
- Slit-lamp biomicroscopy and fundus examination to exclude posterior segment abnormalities
- OCT imaging using SD-OCT

A RS-3000 Advance model has a 5-μm depth resolution in tissue and 20-μm transverse resolution. Each A-scan of this instrument had a depth of 2 mm and comprised 512 pixels, providing a digital depth sampling of 3.9 μm per pixel. For wide-area 3D imaging in the posterior pole, raster scanning over a 9 × 9-mm square area centered on the foveal center was conducted with a scan density of 512 A-scans (horizontal) × 128 B-scans (vertical). For cpRNFL imaging, raster scanning over a 6 × 6-mm square area centered on the optic disc center was conducted with a scan density of 512 A-scans (horizontal) × 128 B-scans (vertical). It took 1.6 seconds to obtain a single 3D data set. Imaging was performed by the researcher and a well-trained examiner after pupillary dilatation, with the examiner rejecting any scans with motion artifacts, poor centration, incorrect segmentation, poor focus, or missing data.

Measurements:

Automated measurements of GCC and RNFL thickness were performed, and thickness and significance maps for GCC and RNFL thickness were generated using in-built software of the RS3000. The GCC thickness was measured between the internal limiting membrane and the outer boundary of the inner plexiform layer (IPL). RNFL thickness was measured in a circle 3.45 mm in diameter consisting of 256 A-scans, which were positioned automatically around the optic disc in each 3D data set.

The parameters from the GCC map are:

Avg. GCC (average GCC thickness for the whole area).

Sup. GCC (average GCC thickness for the superior half of the area).

Inf. GCC (average GCC thickness for the inferior half of the area).

Ethical considerations:

1- No harmful maneuvers were performed or used.

2- An informed consent was taken from all the participants before taking any data or doing any investigations.

3- Explanation of the study aim in a simple manner to be understood by non-medical professions.

4- The researcher only has access to the data used in this study. Study data will not be used without patients' approval.

5- Participants will be allowed to be informed about the study results.

6- Participants were entitled right to withdraw from the study at any time without giving any reasons.

Statistical analysis

Statistical analysis was done on a personal computer using SPSS©version 25.

Data were collected from the imaging equipment (OCT) on CDs, entered ad tabulated on SPSS, then analyzed using appropriate statistical tests. Descriptive analysis:

Continuousdata aredescribedusing mean and standard deviation and Bar charts with standard errors were used to graphically illustrate the difference in means between the two groups of patients.

To test for normality of the data, the Shapiro-Wilk test for normality was applied to choose best comparative analysis tests.

Table (1): Test of Normality for All variables within the Anisometropic amblyopia group of patients:

	Shapiro-Wilk	Interpretation
	Sig.	
Age of the subjects in Years	.192	Data are Normally distributed
Un-aided correction of visual acuity of amblyopic eye	N/A	N/A
Un-aided correction of visual acuity of fellow eye	.519	Data are Normally distributed
Best corrected visual acuity of amblyopic eye	.263	Data are Normally distributed
Best corrected visual acuity of fellow eye	.062	Data are Normally distributed
Average RNFL thickness of fellow eye	.210	Data are Normally distributed
Superior RNFL thickness of fellow eye	.608	Data are Normally distributed
Inferior RNFL thickness of fellow eye	.964	Data are Normally distributed
Average RNFL thickness of amblyopic eye	.921	Data are Normally distributed
Superior RNFL thickness of amblyopic eye	.918	Data are Normally distributed
Inferior RNFL thickness of amblyopic eye	.968	Data are Normally distributed
Average GCC thickness of fellow eye	.086	Data are Normally distributed
Superior GCC thickness of fellow eye	.086	Data are Normally distributed
Inferior GCC thickness of fellow eye	.249	Data are Normally distributed
Average GCC thickness of amblyopic eye	.875	Data are Normally distributed
Superior GCC thickness of amblyopic eye	.991	Data are Normally distributed
Inferior GCC thickness of amblyopic eye	.681	Data are Normally Distributed

*Significance level at p-value ≤0.05.

Comparative Analysis:

The two groups of patients were compared with regards to means of visual acuity measurements, means of RNFL thickness measurements and GCC thickness measurements in both fellow and amblyopic eyes. For normally distributed data, student's (un-related/ independent samples) t-test was used to determine statistical significance of difference between the means. For not normally distributed data, Mann whitney U's test was used.

Within each group, fellow and amblyopic eyes were compared with regards to the same parameters mentioned above. For normally distributed data, paired (related) t-test was used to determine statistical significance of difference between the means. For not normally distributed data, Wilcoxon's rank test was used.

Correlations were made between UCVA and BCVA of amblyopic eyes with RNFL and GCC thickness measurements in the same eye using spearman's coefficient. P-value less than or equal to 0.05 are considered statistically significant.

3. Results

1. Descriptive analysis:

(a) Sample descriptive regarding age were described in terms of mean and standard deviation (SD).

(b) Bar charts representing means and standard deviations were used to graphically illustrate the difference in means between the two treatment groups.

2. Testing for normality:

To test for normality of the data, the Shapiro-Wilk test for normality was applied to choose best data descriptive presentation parameters and comparative analysis tests.

Descriptive analysis

Table (2): Test of Normality for All variables within the Strabismic amblyopia group of patients.

	Shapiro-Wilk Sig.	Interpretation
Age of the subjects in Years	.161	Data are Normally Distributed
Un-aided correction of visual acuity of amblyopic eye	.005	Data are Not Normally Distributed
Un-aided correction of visual acuity of fellow eye	.181	Data are Normally Distributed
Best corrected visual acuity of amblyopic eye	.040	Data are Not Normally Distributed
Best corrected visual acuity of fellow eye	.037	Data are Not Normally Distributed
Average RNFL thickness of fellow eye	.507	Data are Normally Distributed
Superior RNFL thickness of fellow eye	.288	Data are Normally Distributed
Inferior RNFL thickness of fellow eye	.842	Data are Normally Distributed
Average RNFL thickness of amblyopic eye	.012	Data are Not Normally Distributed
Superior RNFL thickness of amblyopic eye	.029	Data are Not Normally Distributed
Inferior RNFL thickness of amblyopic eye	.027	Data are Not Normally Distributed
Average GCC thickness of fellow eye	.394	Data are Normally Distributed
Superior GCC thickness of fellow eye	.663	Data are Normally Distributed
Inferior GCC thickness of fellow eye	.231	Data are Normally Distributed
Average GCC thickness of amblyopic eye	.478	Data are Normally Distributed
Superior GCC thickness of amblyopic eye	.727	Data are Normally Distributed
Inferior GCC thickness of amblyopic eye	.153	Data are Normally Distributed

*Significance level at p-value ≤0.05.

Table (3): Descriptive analysis of the age of each group of patients (Anisometropic and Strabismic)- The mean, standard deviation (SD)

	Group	Mean (SD)
Age	Anisometropic	32.14(17.5)
	Strabismic	27.6(21)

*Significance level at p-value ≤0.05.

The mean age of the sample subjects within the Anisometropic group is 32.14 years old (±17.5). This higher than The mean age of the sample subjects within the Strabismic group (27.6±21).

Table (4): Descriptive analysis of Visual acuity measurements according to each group of patients (Anisometropic and Strabismic) and results of the Non-parametric Mann whitney U test to compare between them

	Group	Mean (SD)	Statistical test: Test statistic	Statistical test: p-value*	Interpretation
Un-aided correction of visual acuity of amblyopic eye	Anisometropic	0.05(<0.0001)	22.500	.022	Statistically significant difference
	Strabismic	0.16(0.14)			
Un-aided correction of visual acuity of fellow eye	Anisometropic	0.41(0.26)	31.500	.156	No Statistically significant difference
	Strabismic	0.44(0.28)			
Best corrected visual acuity of amblyopic eye	Anisometropic	0.25(0.12)	42.000	.541	No Statistically significant difference
	Strabismic	0.36(0.21)			
Best corrected visual acuity of fellow eye	Anisometropic	0.88(0.09)	28.500	.736	No Statistically significant difference
	Strabismic	0.9(0.08)			

*Significance level at p-value ≤0.05.

There is statistically significant difference in means of UCVA of Amblyopic eye between the two groups of patients.

- There are no statistically significant differences between the togrous of patients regarding means UCVA of fellow eyes, BCVA of amblyopic eyes and BCVA of fellow eyes.

Table (5): Descriptive analysis of RNFL measurements by OCT according to each group of patients (Anisometropic and Strabismic) and comparison between them

	Group	Mean (SD)	Statistical test			Interpretation
			Test	Test statistic	p-value*	
Average RNFL thickness of fellow eye	Anisometropic	99.2(12)	Student's t-test	-2.29	0.034	Statistically significant difference
	Strabismic	111.67(8.5)				
Superior RNFL thickness of fellow eye	Anisometropic	101.2(14.2)	Student's t-test	-1.60	0.126	No Statistically significant difference
	Strabismic	112.56(12.52)				
Inferior RNFL thickness of fellow eye	Anisometropic	97.14(12)	Student's t-test	-2.21	0.027	Statistically significant difference
	Strabismic	10.78(10.4)				
Average RNFL thickness of amblyopic eye	Anisometropic	97(19)	Non-parametric Mann-Whitney U test.	34.5	0.24	No Statistically significant difference
	Strabismic	106(17.74)				
Superior RNFL thickness of amblyopic eye	Anisometropic	102(17)	Non-parametric Mann-Whitney U test.	39	0.4	No Statistically significant difference
	Strabismic	109.78(19.45)				
Inferior RNFL thickness of amblyopic eye	Anisometropic	92(21.31)	Non-parametric Mann-Whitney U test.	33	0.2	No Statistically significant difference
	Strabismic	102.22(17.72)				

*Significance level at p-value ≤0.05.

There is a statistically significant difference between both groups of patients regarding means of Average RNFL thickness in fellow eyes and means of Inferior RNFL thickness in fellow eyes. There is no statistically significant difference between the two groups of patients regarding means of Superior RNFL thickness in fellow eyes and Average, Superior and inferior RNFL thickness in Amblyopic eyes.

Table (6): Descriptive analysis of GCC measurements by OCT according to each group of patients (Anisometropic and Strabismic) and results of the Student's t-test to compare between them

	Group	Mean (SD)	Statistical test		Interpretation
			Test statistic	p-value*	
Average GCC thickness of fellow eye	Anisometropic	100.64(7.72)	-0.77	0.45	No Statistically significant difference
	Strabismic	102.67(9.17)			
Superior GCC thickness of fellow eye	Anisometropic	99(6.83)	-1.38	0.18	No Statistically significant difference
	Strabismic	103.44(9.15)			
Inferior GCC thickness of fellow eye	Anisometropic	102(9.832)	-0.15	0.88	No Statistically significant difference
	Strabismic	101.33(9.5)			
Average GCC thickness of amblyopic eye	Anisometropic	98(11.07)	0.23	0.815	No Statistically significant difference
	Strabismic	97.44(10.7)			
Superior GCC thickness of amblyopic eye	Anisometropic	98.57(9.44)	0.42	0.674	No Statistically significant difference
	Strabismic	98.11(10.74)			
Inferior GCC thickness of amblyopic eye	Anisometropic	96.57(12.8)	0.039	0.969	No Statistically significant difference
	Strabismic	96.67(11.2)			

*Significance level at p-value ≤0.05.

There are no statistically significant differences between the two groups of patients regarding means of GCC thickness measurements.

Table (7): Comparison between RNFL measurements by OCT of Amblyopic and fellow eyes within the Anisometropic group of patients:

	Group	Mean (SD)	Paired t-test		Interpretation
			t- statistic	p-value*	
Average RNFL thickness	**Amblyopic**	97(19)	0.86	0.413	No Statistically significant difference
	Fellow	99.2(12)			
Superior RNFL thickness	**Amblyopic**	102(17)	0.39	0.705	No Statistically significant difference
	Fellow	101.2(14.2)			
Inferior RNFL thickness	**Amblyopic**	92(21.31)	1.14	0.284	No Statistically significant difference
	Fellow	97.14(12)			

*Significance level at p-value ≤0.05.

- Thre are no statistically significant differences between Amblyopic eyes and felloweyes within the Anisometropic group of patients regarding means of RNFL thickness measurments.

Table (8): Comparison between GCC measurements by OCT of Amblyopic and fellow eyes within the Anisometropic group of patients.

	Group	Mean (SD)	Paired t-test		Interpretation
			t- statistic	p-value*	
Average GCC thickness	Amblyopic	98(11.07)	2.01	0.075	No Statistically significant difference
	Fellow	100.64(7.72)			
Superior GCC thickness	Amblyopic	98.57(9.44)	.583	0.574	No Statistically significant difference
	Fellow	99(6.83)			
Inferior GCC thickness	Amblyopic	96.57(12.8)	3.31	0.01	Statistically significant difference
	Fellow	102(9.832)			

*Significance level at p-value ≤0.05.

- There is a statistically significant difference between Amblyopic eyes and felloweyes within the Anisometropic group of patients regarding means of Inferior GCC thickness measurements.

- Thre are no statistically significant differences between Amblyopic eyes and felloweyes within the Anisometropic group of patients regarding means of Average and Superior thickness measurements.

Table (9): Comparison between RNFL measurements by OCT of Amblyopic and fellow eyes within the Strabismic group of patients

	Group	Mean (SD)	Non-parametric Wilcoxon test	Interpretation	
			Z- statistic	p-value*	
Average RNFL thickness	Amblyopic	97(19)	-0.65	0.514	No Statistically significant difference
	Fellow	99.2(12)			
Superior RNFL thickness	Amblyopic	102(17)	-0.36	0.721	No Statistically significant difference
	Fellow	101.2(14.2)			
Inferior RNFL thickness	Amblyopic	92(21.31)	-1.38	0.169	No Statistically significant difference
	Fellow	97.14(12)			

*Significance level at p-value ≤0.05.

- Thre are no statistically significant differences between Amblyopic eyes and felloweyes within the Strabismic group of patients regarding means of RNFL thickness measurments.

Table (10): Comparison between GCC measurements by OCT of Amblyopic and fellow eyes within the Strabismic group of patients:

	Group	Mean (SD)	Paired t-test	Interpretation	
			t- statistic	p-value*	
Average GCC thickness	Amblyopic	97.44(10.7)	2.01	0.061	No Statistically significant difference
	Fellow	102.67(9.17)			
Superior GCC thickness	Amblyopic	98.11(10.74	0.583	0.05	Statistically significant difference
	Fellow	103.44(9.15)			
Inferior GCC thickness	Amblyopic	96.67(11.2)	3.31	0.104	No Statistically significant difference
	Fellow	101.33(9.5)			

*Significance level at p-value ≤0.05.

- There is a statistically significant difference between Amblyopic eyes and felloweyes within the Strabismic group of patients regarding means of Superior GCC thickness measurements.

- Thre are no statistically significant differences between Amblyopic eyes and felloweyes within the Strabismic group of patients regarding means of Average and Inferior thickness measurements.

Table (11): Correlation between Visual Acuity measurements and RNFL and GCC measurements by OCTin in Amblyopic eyes in Anisometropicgroup of patients:

		UCVA of amblyopic eye	BCVA of amblyopic eye	Average RNFL thickness of amblyopic eye	Superior RNFL thickness of amblyopic eye	Inferior RNFL thickness of amblyopic eye	Average GCC thickness of amblyopic eye	Superior GCC thickness of amblyopic eye	Inferior GCC thickness of amblyopic eye
Un-aided correction of visual acuity of amblyopic eye	Spearman's Coefficient	1.0	0.369	0.104	0.294	0.009	-.043	0.052	-.083
	P-value*	N/A	0.294	0.775	0.409	0.981	0.906	0.887	0.820
	Interpretation		**No statistically significant correlation**						
Best corrected visual acuity of amblyopic eye	Spearman's Coefficient	0.369	1.0	0.666^{*}	0.685^{*}	0.698^{*}	0.317	0.369	0.436
	P-value*	.294	N/A	0.036	0.029	0.025	0.372	0.295	0.208
	Interpretation	**No statistically significant correlation**		**Statistically Significant moderate positive correlation**			**No statistically significant correlation**		

*Significance level at p-value ≤0.05.

- There is a Statistically Significant moderate positive correlation between BCVA of Amblyopic eye and GCC thickness measurements within the Anisometropic groups of patients.

Table (12): Correlation between Visual Acuity measurements and RNFL and GCC measurements by OCT in Amblyopic eyes Strabismic group of patients.

		UCVA of amblyopic eye	BCVA of amblyopic eye	Average RNFL thickness of amblyopic eye	Superior RNFL thickness of amblyopic eye	Inferior RNFL thickness of amblyopic eye	Average GCC thickness of amblyopic eye	Superior GCC thickness of amblyopic eye	Inferior GCC thickness of amblyopic eye
Un-aided correction of visual acuity of amblyopic eye	Spearman's Coefficient	1.000	$.894^{**}$	.488	.400	.431	.469	.514	.489
	P-value*	N/A	.000	.153	.252	.213	.172	.128	.151
	Interpretation		**Statistically Significant strong positive correlation**	**No statistically significant correlation**					
Best corrected visual acuity of amblyopic eye	Spearman's Coefficient	$.894^{**}$	1.000	.306	.325	.175	.144	.241	.147
	P-value*	.000	N/A	.389	.359	.629	.692	.502	.684
	Interpretation			**No statistically significant correlation**					

*Significance level at p-value ≤0.05.

- There is a Statistically Significant stong positive correlation between UCVA and BCVA of Amblyopic eye within the strabismic groups of patients.

4. Discussion

In this study, we measured RNFL and GCC thickness in amblyopic and fellow eyes with SD-OCT. We divided the patients into two groups anisometropicand Strabismic amblyopic.

Visual acuity between groups:

- There is statistically significant difference in means of UCVA of Amblyopic eye between the two groups of patients.
- There are no statistically significant differences between the two groups of patients regarding means UCVA of fellow eyes, BCVA of amblyopic eyes and BCVA of fellow eyes.

RNFL between groups:

- There is a statistically significant difference between the two groups of patients regarding means of Average RNFL thickness in fellow eyes and means of Inferior RNFL thickness in fellow eyes.
- There is no statistically significant difference between the two groups of patients regarding means of Superior RNFL thickness in fellow eyes and Average, Superior and inferior RNFL thickness in Amblyopic eyes.

GCC between groups:

- There are no statistically significant differences between the two groups of patients regarding means of GCC thickness.

RNFL within group –Anisometropic:

- There are no statistically significant differences between Amblyopic eyes and felloweyes within the Anisometropic group of patients regarding means of RNFL thickness measurments.

RNFL within group –Strabismic:

- Thre are no statistically significant differences between Amblyopic eyes and felloweyes within the Strabismic group of patients regarding means of RNFL thickness measurements.

GCC within group –Anisometropic:

- There is a statistically significant difference between Amblyopic eyes and felloweyes within the Anisometropic group of patients regarding means of Inferior GCC thickness measurements.
- Thre are no statistically significant differences between Amblyopic eyes and felloweyes within the Anisometropic group of patients regarding means of Average and Superior thickness measurements.

GCC within group –Strabismic:

- There is a statistically significant difference between Amblyopic eyes and felloweyes within the Strabismic group of patients regarding means of Superior GCC thickness measurements.
- Thre are no statistically significant differences between Amblyopic eyes and fellow eyes within the Strabismic group of patients regarding means of Average and Inferior thickness measurements.

Correlations:

- There is a Statistically Significant moderate positive correlation between BCVA of Amblyopic eye and GCC thickness measurements within the Anisometropic groups of patients.
- There is a Statistically Significant stong positive correlation between UCVA and BCVA of Amblyopic eye within the strabismic groups of patients.

As mentioned earlier, the controversy about involvement of the retina in the pathogenesis of amblyopia persists till as soon as the year 2017.

In our study also, results came up with variations regarding the different measurements.

Our results were similar to studies that reported No statistically significant differences between normal eyes and amblyopic eyes (whether anisometropic or strabismic) regarding RNFL thickness.

For example, **Ersan et al.** (**2013**) conducted a study that compares patients with strabismus (35 patients) and patients with anisometropia (30 patients) were compared with their fellow eyes and age- and gender-matched healthy eyes (40 participants). The study concluded that Amblyopia is not associated with a decrease in RNFL thickness in strabismic or anisometropic amblyopia.

According to **Ersan et al. (2013)** In the anisometropic group, the inter-eye differences in RNFL thickness parameters seemed to be related to the refraction differences between the amblyopic eyes and their fellow eyes. Our study might have touched base with such hypothesis as it revealed. Statistically Significant moderate positive correlation between BCVA of Amblyopic eye and GCC thickness measurements within the Anisometropic groups of patients.

The same study also concluded that RNFL thickness did not differ between strabismic amblyopic, anisometropic amblyopic, and control eyes (P >.05). This is similar to our findings regarding means of Superior RNFL thickness in fellow eyes and Average, Superior and inferior RNFL thickness in Amblyopic eyes.

In contrast to these results, **Kasem et al. (2017) (Auckland, Newzealand)** found out that the unilateral amblyopic eyes were prone to have a higher CMT and thicker global RNFL compared to those of the sound fellow eyes.

Regarding thickness of GCC, our study results conclude that there is a statistically significant difference between Amblyopic eyes and fellow eyes within the Strabismic group of patients regarding means of Superior GCC thickness measurements. This finding is similar to what **Tugcu (2013**) that patients with strabismic amblyopia presented with significant reduction in GCC thickness () [(62)].

On the contrary, **Syunsuke et al. (2014)** concluded in their study that there was no significant difference in thickness between amblyopic and fellow eyes regarding both types: Anisometropic and strabismic [(63)].

In addition, **Andrea et al. (2014)** used TD-OCT image segmentation methodology involving the entire macular area, extracting seven retinal layers.

They enrolled 38 patients (mean age 32.4±17.6 years; range 6–67 years) with unilateral amblyopia. 17 patients had strabismic amblyopia, 11 patients had anisometropic amblyopia, and 10 patients had combined amblyopia (strabismus and anisometropia).

There was significant changes in the GCC layer in the pericentral region and in the OPL layer calculated for the total macula and measured in the peripheral region.

The great variability in the results of the studies in question was stated by a systematic review by **Avram (2017)** of 30 clinical trials regarding amblyopia evaluation with Optical Coherence Tomography. The research articles analyzed were published between 2006 - 2016 and were identified on PubMed database.

Avram (2017) found that 19 research studies focused on macular and nerve optic changes, 7 on choroidal changes and 6 on retinal changes after occlusion. The results were discussed according to the type of amblyopia, alteration of macular thickness, optic nerve changes, ganglion cell layer changes, and alteration of choroidal thickness.

Avram (2017) concluded that the results were of great variability, and it seemed that macula and choroid involvement is more frequently suggested compared with optic nerve involvement.

Conclusion

Our study is done to compare the retinal nerve fiber layer (RNFL) thickness and ganglion cell complex (GCC) in amblyopic and fellow eyes using SD-OCT.

The study showed there was no significant different in RNFL between amblyopic and fellow eyes in two groups of anisometropic and strabismic amblyopia.

There was a statistically significant difference between Amblyopic eyes and fellow eyes within the Anisometropic group of patients regarding means of Inferior GCC thickness measurements.

There was a statistically significant difference between the two groups of patients regarding means of Average RNFL thickness in fellow eyes and means of Inferior RNFL thickness in fellow eyes.

There is a Statistically Significant moderate positive correlation between BCVA of Amblyopic eye and GCC thickness measurements within the Anisometropic groups of patients.

We recommend further researches toadditional histopathological studies with a greater number of patients are required to confirm these findings. And studies correlate RNFL and GCC thickness with functional outcome after treatment (amblyopic therapy).

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