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Macular thickness in Amblyopic children measured by optical coherence tomography

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Abstract

This prospective study was performed to compare macular thickness and volume between the sound and the amblyopic eye, in children with amblyopia, using optical coherence tomography. Thirty-three amblyopic patients aged from 4 to 10 years were included. Amblyopic eyes were considered as the case group and their fellow eyes as controls. Macular thicknesses of all eyes were measured by optical coherence tomography (OCT) in the center (foveola), 1 mm ring (fovea), and 3 and 6 mm rings and compared. Mean age was 6.30± 1.99, the mean refractive error was 5.68 ±1.97 SD and 4.80 ± 2.54SD in amblyopic and normal eye respectively, 17 patients were having strabismic amblyopia and 16 with both strabismic plus anisometropic amblyopia. Although the average macular thickness was not different between the amblyopic eye and controls, the foveolar thickness in eyes with amblyopia was significantly greater than the controls and there was a significant difference in some other areas of the macula. In conclusion, there seems to be a difference in some of the morphological measurements between the amblyopic and fellow eyes in patients with unilateral amblyopia.

Key words: Macular thickness, Amblyopic children, optical coherence tomography

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قياس سمك البقعة الصفراء في الاطفال ذوي غمشة بواسطة التصوير المقطعي للتماسك البصري

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الملخص:

وقد أجريت هذه الدراسة المستقبلية للمقارنة سماكة البقعة الصفراء الشبكية والحجم بين العين السليمة والعين الغمشة، في الأطفال الذين يعانون من الحول، وذلك باستخدام التصوير المقطعي البصري التماسك. وأدرجت ثلاثة وثلاثين مريضا ذو غمشة الذين تتراوح أعمارهم بين 4-10 سنة. واعتبرت عيون غمشة كمجموعة حالة و عيونهم السليمة كضوابط. تم قياس سمك البقعة لبصفراء في كل العيون بواسطة التصوير المقطعي التماسك البصري في المركز (النقيرة) 1 مم و 3 و 6 ملم حلقات متوالية والمقارنة بينهم . وكان متوسط العمر 6.30 ± 1.99، كان خطأ 5.68± و 1.97 2.54 ± 4.80في العين غمشة والعادية على التوالي، 17 مريضا كانوا يتناولون الحول حولي و 16 مع الحول على حد سواء حولي بالإضافة إلى تفاوت الانكسار. على الرغم من أن متوسط سمك البقعي لا يختلف بين العين غمشة والضوابط، وكان سمك النقيري في العينين مع الحول أكبر بكثير من الضوابط وكان هناك اختلاف كبير في بعض المناطق الأخرى من البقعة. في الختام، يبدو أن هناك اختلاف في بعض القياسات المورفولوجية بين العينين غمشة وزملائه في المرضى الذين يعانون من الحول من جانب واحد.

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1. Introduction

Amblyopia is a unilateral or bilateral reduction of visual acuity usually caused by an abnormal visual experience early in life during the development of the visual system [Liu H et al., 2010].

This condition could be secondary to visual deprivation or abnormal ocular interaction and the most common sub-types are: strabismic, anisometropic and form deprivation; furthermore, these can co-exist. Strabismic amblyopia is most commonly associated with an early onset (<6-8 years of age) of constant unilateral strabismus, due to the absence of bifoveal fixation, the two eyes receive different visual images, causing confusion and diplopia. To eliminate these problems, the visual system actively inhibits or suppresses the image from the turned eye. This active inhibition over time causes cortical spatial changes that result in the diminution of visual acuity [Bedell and Flom ,1981].

Anisometropic amblyopia is caused by an uncorrected refractive error in which the difference between the corresponding major meridians of the two eyes is at least l D [Schapero ,1971].

The amblyopic process may have an effect on various levels of the visual pathway. Shrinkage of cells in the lateral geniculate nucleus that receive input from the amblyopic eye has been reported [Wiesel , 1963; Von Noorden , 1992].

Retinal involvement accompanying amblyopia is controversial [Deline et al.,1998]. However, in recent years; reinvestigations using fundus photographs have suggested the presence of organic changes in amblyopic eyes, which had previously been assumed to be normal [Lempert , 2000].

Optical coherence tomography (OCT), an optical analog of ultrasound [Fujimoto et al., 2000], is unique on account of its combined features: An objective method of quantitatively determining the macular characteristics, ability to produce high resolution and cross-sectional images of the retina and optic nerve accurately and precisely visualizes the retinal structure in vivo with a resolution of 10 to 17 µm, and yet purely noninvasive [Massin et al., 2001, Hee et al., 1995].

Our aim was to compare macular thickness and volume between the normal and the amblyopic eye, in children with unilateral amblyopia due to strabismus or anisometropia, using 3D OCT, based on spectral domain (SD) detection technology.

2. Patients and methods

This prospective case- control study was performed on 33 children presenting to squint clinic at Al-Keish polyclinic / Benghazi-Libya with unilateral amblyopia at the period from September 2016 to February 2017. According to the tenets of the Declaration of Helsinki for research in human subjects, the process and the benefits were explained to the parent's child.

Inclusion criteria included amblyopic children under the 18 years of age due to strabismus or hyperopic anisometropic amblyopia or both.

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Exclusion criteria included ocular disease, previous ocular surgery, myopia, neurological disease, nystagmus, and uncooperative children unable to keep fixation.

Amblyopia was defined as a best corrected visual acuity (BCVA) difference of two Snellen lines or more (>1 log unit) between both eyes.

Any difference in cycloplegic spherical equivalent equal or greater than 1 D between fellow eyes was considered as anisometropia.

Amblyopic eye was considered as the case group and their fellow eye as controls.

The clinical examinations included visual acuity (VA) testing, cycloplegic refraction after pupillary dilation with 1% cyclopentolate hydrochloride, slit-lamp examinations, cover and cover–uncover test, extraocular muscles movements, and fundoscopy.

The BCVA was transformed to the logarithm of the minimum angle of resolution (logMAR) units for the statistical analysis.

The macular thickness was measured by Topcon 3D OCT -2000(Ver.8.01),

[Scan mode 3D (6.0X6.0mm-512x128)]

Macular scans were evaluated with the *basic* program, displaying the results in three concentric circles, as shown in [Figure 1]. Thickness of the center (foveola), 1 mm circle (fovea), the inner and outer rings (Macula) were each divided into 4 quadrants (superior, nasal, temporal and inferior zones), having 3 and 6 mm in diameter, respectively. An average retinal thickness was reported for each of the nine regions, as well as the foveal minimum thickness and total macular volume. Each OCT was performed by the same operator and only the images centered on the fovea were accepted.

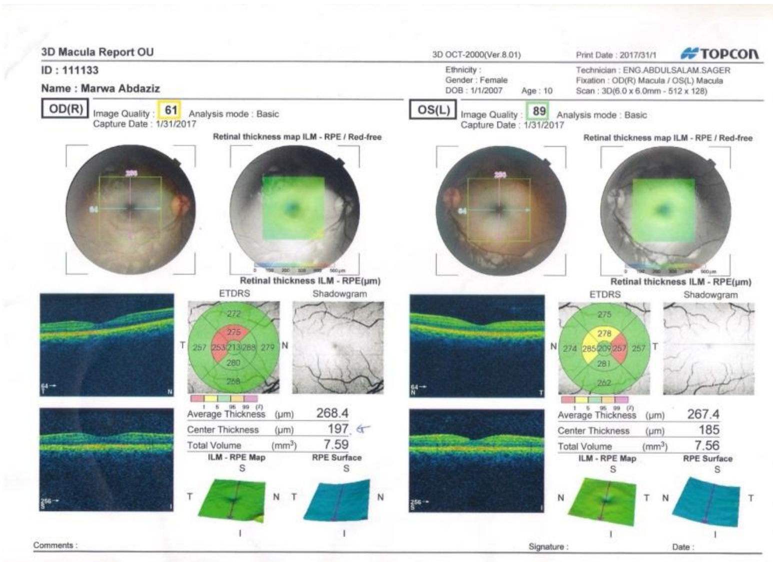

Figure 1 Sample OCT images from a patient with strabismic amblyopia

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3. Statistical analysis

The student paired *t*-test was used to determine whether the differences between the values of the amblyopic and fellow eyes were significant. *P*-values of less than 0.05 were considered to be statistically significant and analysis was done by Excel 2010.

4. Results

33 patients were included in this study, 20 male (60.60%) and 13 female. Age range from 4 to 10 years with mean age ± standard deviation (SD) of children was 6.30± 1.99.

The right eye was involved in 20 child (60.60%) and left eye in 13 child. 17 (51.50%) children were diagnosed as having strabismic amblyopia and 16 with combined strabismic plus anisometropic amblyopia. All the children were hypermetrope with esotropia.

The mean BCVA was 0.4 ±0.23 logMAR in the amblyopic eyes and 0.15±0.27

Log MAR in the control eyes. The mean spherical equivalent was 5.68 ±1.97 D in the amblyopic eyes and 4.80 ± 2.54 D in the control eyes. (Table 1)

Table1: clinical characteristic of children included in the study

	Amblyopic eyes (n=33)	Control eyes (n-33)
Refractive error (diopter)	5.68 ±1.97	4.80 ± 2.54
BCVA (logMAR)	0.40±0.23*	0.15±0.27

Notes: Values are shown as mean ± standard deviation.

The marked differences (*) were statistically significant (P<0.05) by student t-test.

Abbreviations: BCVA, best corrected visual acuity; logMAR, logarithm of the minimal angle of resolution.

Central (foveolar) thickness was significantly greater in the amblyopic eye; by contrast, the thickness in the inner nasal macular areas of the amblyopic eye was significantly reduced.

Macular volume and retinal thickness in some the other macular areas were reduced in amblyopic eyes but this was not statistically significant as seen in (Table 2) and [Figure 2].

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Table 2: Comparison of the macular retinal thickness and macular volume between the amblyopic and control eyes.

Thickness (µm) mean±SD	Amblyopic eye	Control eye
Foveola	248.66±46.46*	221.54±45.04
Average foveal (1 mm)	261.09±36.28	252.90±32.37
Inner macula (3 mm)		
Nasal	283.36±29.48*	297.66±15.48
Superior	288.39±24.62	290.96±25.04
Temporal	277.18±21.45	286.12±20.02
Inferior	290.57±25.75	286.30±33.28
Outer macula (6 mm)		
Nasal	277.72±26.52	278.00±15.29
Superior	256.93±44.49	272.54±17.94
Temporal	269.30±23.90	273.54±22.10
Inferior	274.90±22.58	275.06±18.83
Average thickness	273.46±22.11	278.07±13.75
Volume (mm3)	7.73±0.62	7.85±0.37

SD: standard deviation

The marked differences (*) were statistically significant ($P<0.05$) by student t-test.

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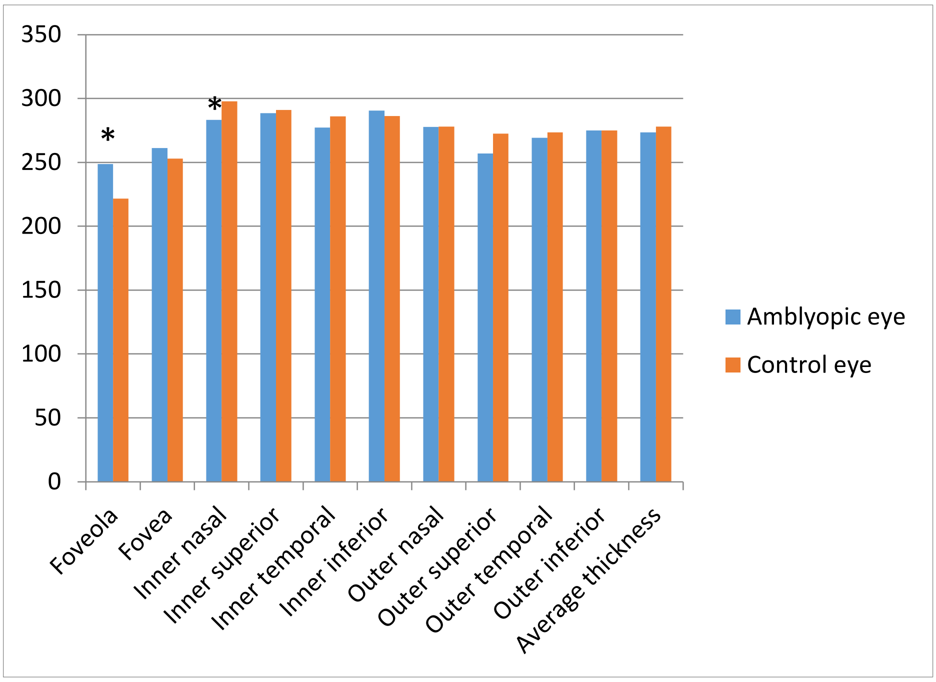

Figure 2: Comparison of macular thickness between amblyopic and control eyes

The marked differences (*) were statistically significant (P<0.05) by student t-test.

5. Discussion

Lateral geniculate nucleus alterations have been well established in animals and in humans, with shrunken cells in layers supplied by the amblyopic eye [Wiesel , and Hubel, 1963; Von Noorden and Crawford , 1992]. These changes are thought to be caused by retrograde inhibition originating in the visual cortex [Demer et al., 1991].

Retinal involvement is still a controversial issue. Recent technology has given us the opportunity of studying the retina in vivo and this has led to a wide number of studies in amblyopic patients, either using OCT, scanning laser polarimetry [Baddini-Caramelli et al., 2001], or confocal scanning laser ophthalmoscopy [Miki et al., 2010] in order to assess retinal changes. Several works using OCT have focused on the macula, the optic nerve or both [Huynh et al. 2009], with contradictory results.

Increased macular thickness and decreased foveal depression have been reported in amblyopic patients using OCT [Altintas O et al. 2005].The reason can be related to lack of ganglion cells apoptosis which normally occurs shortly after birth in healthy infants [Yen MYet al. 2004].

The Sydney Childhood Eye Study, by Huynh et al. OCT scan data was studied in 3529 patients with strabismic or anisometropic amblyopia, showing significant greater foveal minimum thickness in amblyopic than in non-amblyopic eyes, as well as a greater central macular thickness in amblyopic eyes, although the latter was not significant. The inner macular ring was also significantly thinner in amblyopic children, with no difference found in outer macular ring thickness [Huynh SC et al. 2009].

Yoon *et al* found no significant difference in macular thickness in 31 patients in a study on 14 children with unilateral amblyopia and strabismus [Sang Yoon et al., 2005]. Altintas et al showed no significant difference between macular thickness and volume in amblyopic and non-amblyopic children [Altintas et al., 2005].

Filipe Silva *et al* found the foveal minimum thickness was significantly greater in the amblyopic eye; by contrast, significantly reduced thickness was found in the inner nasal, inner inferior and outer inferior macular areas of the amblyopic eye [Filipe Silva et al., 2012], and this result is to some extent similar to our study results as we found that the thickness of foveola increased significantly in amblyopic and the thickness in the inner nasal macular areas of the amblyopic eye was significantly reduced.

This study was limited by the small number of patients included in it.

In conclusion, there seems to be a difference in macular thickness between both eyes in patients with unilateral amblyopia due to strabismus or anisometropia, at least in some areas suggests that although amblyopia primarily affects the visual cortex, it is also a process that leads to secondary changes at the retinal level. However, prospective studies with larger case series and more advanced instruments measuring a wider variety of parameters are needed.

And we highly recommend earlier screening for causes of amblyopia and close follow- up and referral of high- risk patients.

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