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Research Article

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Optical Coherence Tomography Analysis of Macular Thickness in Children with Amblyopia

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Abstract

Purpose: *To compare central, inner and outer ring macular thickness measured with optic coherence tomography (OCT) in children with unilateral amblyopia. To analyze the differences in retinal structure among strabismic, anisometropic and combined (strabismus + anisometropia) amblyopia.*

Background: *Amblyopia is a reduction of visual acuity in one or both eyes due to an abnormal visual input during the development of the visual system. It is mainly caused by strabismus, anisometropia or high bilateral refractive errors, and visual deprivation. Although it has been always said that the amblyopic eye is an otherwise healthy eye, the imaging techniques developed lately, especially OCT and angio OCT, may show differences in retinal structures that could have a role in the development of amblyopia and/or its response to treatment.*

Methods: *Retrospective review of amblyopic children followed up in our hospital. 60 children with unilateral amblyopia due to anisometropia and/or strabismus, with a good quality OCT exam, were included. We analyzed 9 thickness measurements: central macular thickness (1mm ring) and 4 sectors in inner (3mm) and outer (6mm) rings.*

Results: *Data from 60 children is included. Mean retinal thickness at the central 1mm ring was 249.15µm for amblyopic eyes vs 238.3µm for fellow eye (p=0.000). For the thickness in the other 8 sectors for inner and outer rings no statistically significant differences were found. The central retina measurement was thicker in the anisometropic amblyopia group (p=0.003), but no statistically significant difference was found in the strabismic (p=0.066) and combined group (p=0.055).*

Conclusions: *Central retinal thickness was significantly greater in amblyopic eyes compared to fellow eyes. This difference in thickness is also statistically significant in patients with anisometropia but not in those with strabismus or strabismus + anisometropia. Further studies with more patients are recommended.*

Keywords: Amblyopia, Anisometropia, Strabismus, Macular thickness, OCT

Introduction

Amblyopia is described as a reduction of visual acuity in one or, less often, both eyes due to an abnormal visual input during the development of the visual system. Regarding etiology, there are three main causes: strabismus, refractive error (anisometropia or high bilateral refractive errors), and visual deprivation (due to ptosis, corneal opacification, congenital cataract,…). It has always been said that the amblyopic eye is an otherwise healthy eye, historically opting for a cortical origin. However, the imaging techniques developed lately may show differences in retinal structures. Optical coherence tomography (OCT) and angio OCT can acquire images of the retinal layers and its vasculature. We can compare the structure, thickness and/or vessel distribution of these layers between amblyopic and fellow eyes. The differences that we could find at such histological level could have a role in the development of amblyopia and/or its response to treatment. Some published works lately show a difference in the nerve fiber layer and, most of all, in the ganglion cell layer [1-5].

That is why we plan a review of patients with unilateral amblyopia in our center to compare central, inner and outer ring macular thickness measured with optic coherence tomography (OCT) in children with unilateral amblyopia. Besides, to analyze the differences in retinal structure among strabismic, anisometropic and combined (strabismus + anisometropia) amblyopia

Methods

We perform a retrospective review of amblyopic children followed up in our hospital. We review the notes of children with unilateral amblyopia due to anisometropia and/or strabismus, with a good quality OCT exam, from our hospital in the last two years. OCT images were obtained either with OCT 1000 (Topcon) or Nidek RS330 Scan Duo.

The inclusions criteria were:

- Age: >3 and < 13 years old who have a recorded reliable visual acuity and good quality macular OCT image
- A difference of at least 2 lines in best corrected visual acuity
- Amblyopia due to anisometropia, strabismus or both

The exclusion criteria were:

- Deprivational amblyopia
- Systemic pathology or treatments that could affect vision or refractive error
- Bad quality OCT images

Data recorded was: demographic data (age, gender,…), best corrected visual acuity, refraction (dry and cycloplegic refraction), ocular motility, cover test, slit lamp anterior segment examination and fundus exam, macular OCT data (9 thickness measurements: central macular thickness (1mm ring) and 4 sectors in inner (3mm) and outer (6mm) rings).
SPSS was used for statistical analysis of paired samples.

Results

At the end of the clinical files revision, data from 60 children was included.

Regarding demographic data, the mean age in the group is 7 years-old (3-10years). Regarding gender we found a balance as there are 30 girls and 30 boys, all of them caucasian.

As regards of amblyopia, in 31 cases, right eye amblyopia was diagnosed, compared to 29 cases of left eye amblyopia. On the type of amblyopia, there are 32 cases of anisometropic amblyopia, 14 of strabismic amblyopia and 14 of strabismic + anisometropic amblyopia.

The retinal thickness data of all segments in both amblyopic and fellow eye can be seen in Table 1. Mean retinal thickness at the central 1mm ring was 249.15µm for amblyopic eyes vs 238.3µm for fellow eye (p=0.000). For the thickness in the other 8 sectors for inner and outer rings no statistically significant differences were found. In Tables 2, 3 and 4 we can see the macular thickness of these sectors as per the different types of amblyopia (anisometropic, strabismic and combined). The central retina measurement was thicker in the anisometropic amblyopia group (p=0.003), but no statistically significant difference was found in the strabismic (p=0.066) and combined group (p=0.055).

Table 1: Comparison of 9 sectors of macular thickness means between amblyopic and fellow eyes (n=60)

	Amblyopic eye	Fellow eye	Significance (p)
Central macular thickness (1mm)	249.15	238.3	0.000
Inner 3mm -Temporal	294	294.45	0.751
-Inferior	303.83	304.61	0.685
-Nasal	314.2	312.85	0.352
-Superior	312.07	310.98	0.581
Outer 6mm -Temporal	274.41	272.07	0.114
-Inferior	283.25	279.6	0.010
-Nasal	298.67	294.37	0.072
-Superior	286.8	282.9	0.040

Table 2: Comparison of 9 sectors of macular thickness means between amblyopic and fellow eyes in anisometropic amblyopias (n=32)

	Amblyopic eye	Fellow eye	Significance (p)
Central macular thickness (1mm)	246.81	234.18	0.003
Inner 3mm -Temporal	290.25	291.40	0.613
-Inferior	299.06	300.37	0.471
-Nasal	307.78	308.53	0.729
-Superior	307.41	307.16	0.930
Outer 6mm -Temporal	271.69	269.5	0.311
-Inferior	284.37	278.78	0.008
-Nasal	296.44	293.16	0.182
-Superior	284.03	281.81	0.276

Table 3: Comparison of 9 sectors of macular thickness means between amblyopic and fellow eyes in strabismic amblyopias (n=14)

	Amblyopic eye	Fellow eye	Significance (p)
Central macular thickness (1mm)	253.07	241.21	0.066
Inner 3mm -Temporal	293.78	293.07	0.781
-Inferior	301	307.21	0.337
-Nasal	315.64	314	0.317
-Superior	309.21	310.21	0.847
Outer 6mm -Temporal	275.57	272.86	0.417
-Inferior	279.5	277.71	0.594
-Nasal	297.14	298	0.593
-Superior	287.78	284.43	0.153

Table 4: Comparison of 9 sectors of macular thickness means between amblyopic and fellow eyes in combined amblyopias (n=14)

	Amblyopic eye	Fellow eye	Significance (p)
Central macular thickness (1mm)	250.57	244.78	0.055
Inner 3mm -Temporal	302.78	302.78	1.000
-Inferior	317.57	311.71	0.084
-Nasal	327.43	321.57	0.090
-Superior	325.57	320.50	0.018
Outer 6mm -Temporal	279.5	277.14	0.381
-Inferior	284.43	283.36	0.580
-Nasal	305.29	293.5	0.173
-Superior	292.14	283.85	0.001

Discussion

The visual system is inmature at birth and a great dinamism in visual development is observed during the first years of life. Different anatomical and physiological factors may influence the developing vision in children. Good acquisition of fixation and following reflexes is needed for normal development of pediatric macula. Possible involvement of the retina in amblyopia has been traditionally controversial. At birth, the anterior structures of the eye are better developed than the posterior ones [6]. The foveal differentiation is incomplete during the first stages of life and occurs relatively late in comparison with other structures of the eye. The different layers of the retina increase their thickening along the first months of life.

In addition to the growth of the eyes postnatally, the central nervous system is also growing. The visual cortical synapses are ongoing during the first months of life [7]. Some studies have suggested that there isn´t difference in macular thicknesses in amblyopic children. On the other hand, other autors have shown that foveal thickness is affected in anisometropic amblyopia [8].

The binocular vision disruption may play a role in the abnormal development of retinal layers. This facts could explain some of the abnormalities seen in our study, but not why the growth of central macula is greater in anisometropic amblyopia, but not in strabismic amblyopia. The explanation to this observation could be that the fovea with strabismic amblyopia receive a clear image, but the brain in unable to process the conflicting information from the two eyes [9]. Changes in number, structure or function of retinal cells or interstitial substance could explain the increased macular thickness. The nerve fiber, ganglion cell, and inner plexiform layers are absent from the developed fovea. Our findings show that the fovea is the more thickened structure, so it is not probable that ganglion cells changes be the principal cause as it was suggested by other authors [10]. It has also been suggested that amblyopia could affect the normal progressive apoptosis of ganglion cells, eventually leading to a thicker layer [11]. Another possible explanation could be an endothelial change because almost all blood vessels in the fovea are capillaries, and the central capillary-free zone in the macula is only about 0.4 mm in diameter.

Foveal development includes cell rearrangements and alterations in cone shape after birth [12]. Axial length and refractive error have been shown to affect the measurements of retinal nerve fibre layer by OCT [13]. This layer is measured thicker in hyperopic eyes, about 1.671 microns for each diopter of hyperopia [13,14]. The effects of refraction may explain in part our findings in hyperopic patients, but not in myopic ones.

To isolate one particular system and study its role in changing visual functions becomes a very complex task. Neurobiochemical and anatomo-pathological studies will be needed to analyze which is the intim mechanism of this foveal zone growth increase in anisometropic amblyopic eyes.

Conclusions

Central retinal thickness was significantly greater in amblyopic eyes compared to fellow eyes. This difference in thickness was also statistically significant in patients with anisometropia but not in those with strabismus or strabismus + anisometropia. Whether this could have a role in the genesis of amblyopia or not, may need to be studied in further trials.

Conflicts of Interest

The authors declare that they have no conflicts of interest or potential conflicts of interest related to the study.

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