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Research Article

Evaluation of Photoreceptor Outer Segment Length in Children with Unilateral Strabismic Amblyopia

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Abstract

Objective: To assess the photoreceptor outer segment (PROS) lengths of amblyopic and non-amblyopic fellow eyes of children with strabismus using spectral-domain optical coherence tomography (SD-OCT).

Material and Methods: Thirty-four strabismic amblyopia children without anisometropia (10.3 ± 4.9 years) were enrolled in this observational, cross-sectional study. The PROS length was defined as the distance from the inner surface of ellipsoid zone to the inner surface of retinal pigment epithelium (RPE). The amblyopic and non-amblyopic fellow eyes were compared with each other.

Results: The mean spherical equivalance in the amblyopic and non-amblyopic fellow eyes of strabismic children was 2.1 ± 3.0 diopters (D) and 1.6 ± 2.8 D, respectively (p: 0.478). Although the mean PROS length was lesser in amblyopic eyes (52.7 ± 3.8 μm) than the non amblyopic eyes (54.1 ± 3.7 μm), it was not statistically significant (p: 0.125).

Conclusions: The amblyopic process may have no significant effect on the PROS length in children with unilateral strabismic amblyopia.

Keywords: *Photoreceptor Outer Segment; Amblyopia; Strabismus*

Introduction

Ambliyopia is a visual development disorder that occurs in the result of significant visual deprivation in one or both eyes or abnormal binocular interaction. This disease can be reversed by appropriate treatment during the critical period of visual development [1-3]. It can be classified as strabismic, anisometropic and deprivation [4,5]. Strabismus and anisometropia are the most common causes of ambliyopia [6].

In ambliyopia, physiological changes could occur different levels of visual pathway from striate cortex to retina and retinal changes are still not well understood [7]. There are several studies on retinal thickness [8] and choroidal thickness [9,10] made with optical coherens tomography (OCT) in unilateral amblyopia. Possible abnormal development of microstructures of the photoreceptors -as outer nuclear layer- has shown in amblyopic eyes [2]. The incoming light is transmitted to the organelles in the outer segment of the photoreceptor layer (PROS), which is converted to a visual signal due to its silium structure and rich protein content. Thus PROS layer has a significant characteristic effect on vision [11,12]. The correlation of PROS length and visual acuity has been shown in many studies [13-15]. However, there are not any studies evaluating the PROS length in amblyopic eyes and how it is altered by strabismus. In the current study, we aimed to investigate variability of the PROS length, which is directly related to the vision, in the strabismic amblyopia.

Materials and Methods

Thirty-four chidren (22 female, 12 male) with unilateral strabismic amblyopia were included in this cross-sectional study. The study was conducted in the Department of Ophthalmology at Okmeydani Training and Research Hospital. It was approved by the Institutional Ethical Board of Marmara University and adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from a parent or legal guardian of the participants.

Unilateral amblyopia was defined as a condition where the decimal BCVAs were less than 0.8 in the amblyopic eye. All patients had manifest esotropia on the cover test. For all patients, amblyopia treatment has been prescribed previously. Patients with an interocular difference in spherical equivalent of more than 1.0 diopters (D), previous intraocular surgery, nystagmus, glaucoma, neurological or retinal disease were excluded from the study.

A detailed ophthalmologic examination was performed in all participants included best corrected visual acuity (BCVA), cycloplegic refraction after pupillary dilatation (1% cyclopentolate hydrochloride and 1% tropicamide), cover and alternate cover testing, extraocular movement, slit-lamp biomicroscopy and fundus examination. The snellen BCVA was converted to logarithm of the minimum angle of resolution (logMAR) unit for statistical analyses.

Measuerement of PROS length

SD OCT scans were performed with OCT Spectralis (Spectralis, Heidelberg Engineering, Heidelberg, Germany). The entire macular area was scanned, and the following scan acquisition parameters were required: dense volume scan (30° × 25°, roughly 9 × 7.5 mm), 31 B-scans each spaced 244 μm apart, automatic real-time mean of 20, and high speed (512 A-scans/B-scan). The PROS length was defined as the distance from inner surface of ellipsoid zone to inner surface of RPE. All SD OCT sections through the fovea were examined carefully and the measurements were performed manually using digital calipers at the foveal center (foveola) where the ellipsoid zone and foveal bulging formed (Figure 1). Two experienced observers (G, D), who were masked to the patients' information, measured the PROS length independently, and the average of the two observers was used for the statistical analyses.

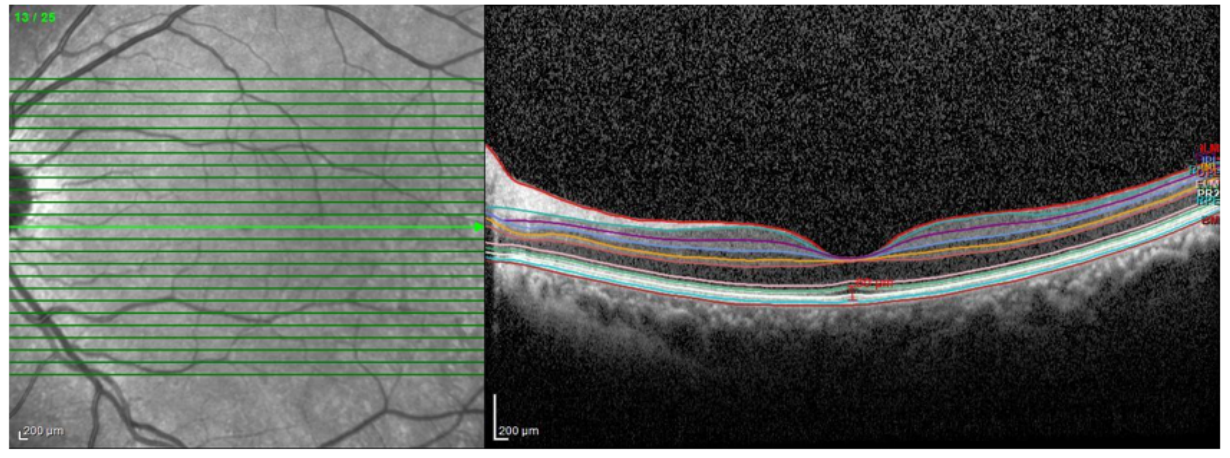

Figure 1: *Measurement of Photoreceptor outer segment length (PROS) after automatic segmentation. Green-colored line represents ellipsoid zone, turquoise colored line represents RPE, and the distance between these two lines represent PROS length.*

SPSS 17.0 (SPSS, Chicago, Illinois, USA) was used for statistical analyses. Continuous variables were given as mean ± standard deviations and categorical variables were defined as percentages. Normality of continuous variables' distribution was tested using Kolmogorov-Smirnov test. Normally distributed continuous variables were compared using independent samples t test. All analysis were two sided and considered significant at a p value of < 0.05.

Results

This study analyzed 34 patients with unilateral strabismic amblyopia. The mean age of the patients was 10.3 ± 4.9 years. The mean logMAR BCVA in amblyopic eyes was significantly worse than fellow eyes (p < 0.001). The mean spherical equivalance was similar in both amblyopic and fellow eyes (p: 0.478). Table 1 summarizes the demographic and clinical data of the patients.

	Amblyopic Eyes	Non-Amblyopic Fellow Eyes
Age	10.3 ± 4.9	
Gender (Male:Female)	12:22	
Best corrected visual acuity (LogMAR)	0.26 ± 0.19	0.0 ± 0.0
Spherical equivalent (diopters)	2.1 ± 3.0	1.6 ± 2.8
PROS length (micron)	52.7 ± 3.8	54.1 ± 3.7

Table 1: *Demographic and clinical characteristics of the patients.*
PROS: Photoreceptor Outer Segment Len.

The mean PROS length tended to be lower in amblyopic eyes than non-amblyopic fellow eyes, but the difference was not statistically significant (52.7 ± 3.8 µm vs 54.1 ± 3.7 µm; p: 0.125) (Figure 2).

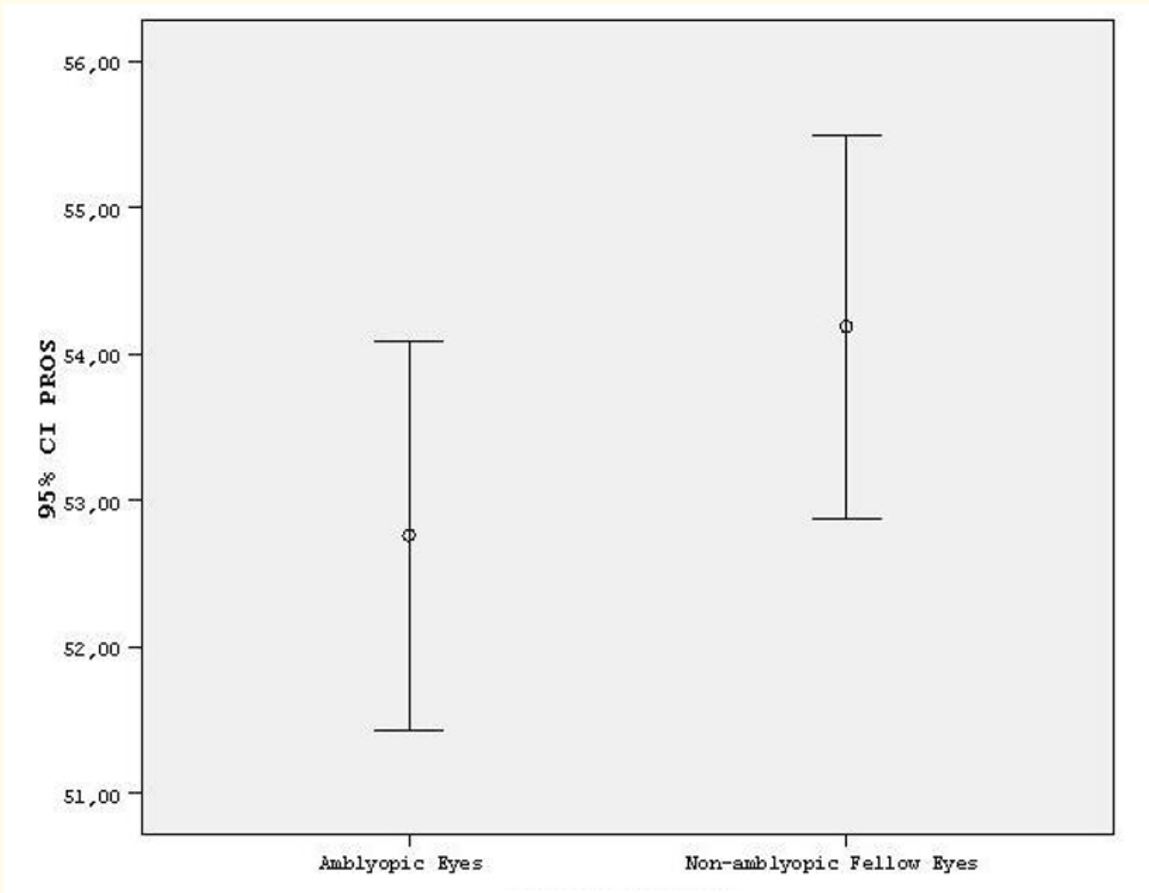

Figure 2: *95% CI PROS (Confidence interval Photoreceptor Outer Segment lengths [µm]). The PROS length in non-amblyopic eyes was greater than amblyopic eyes as shown in the graphic.*

Discussion

The photoreceptors are specialized neurons that play an essential role in the initial step of vision. The outer segment functions in the capture of light and its conversion into electrical signals in a process known as phototransduction. Since mutations within most of phototransduction proteins have been associated with retinal diseases, the PROS constitutes one of the most important parts of the retina. Although there are many OCT studies related with retinal thickness in amblyopia in the literature, none of them did not specifically address this issue [16-18]. From this perspective, our study is the first to evaluate the PROS length in strabismic amblyopia. On the other hand, though the pathogenesis of amblyopia is based on cortical structure, the retinas of amblyopes are still under investigation whether any morphological change can be detected.

In our study, we found that the mean PROS length was slightly less in the amblyopic eyes than the non-amblyopic fellow eyes in chidren with strabismus but this difference was not statistically significant. Most of the studies in the literature have examined the average foveal thickness in amblyopia. Surely, evaluating the layers within the fovea will be more accurate to make judgements because a minimal change in one layer may not be discovered when summing up all of the layers together into overall thickness. When examining retinal layers, Chen., *et al.* did not report any difference in the intra-retinal layers in the foveas of children with anisometropic amblyopia [7]. Similarly, Park., *et al.* also did not find any differences in any retinal layers in central fovea in amblyopic eyes [18]. Conversely, Nishi., *et al.* declared shorter outer segments in the central fovea of anisohypermetropic amblyopic eyes compared with fellow eyes, which agrees with our results [2]. However, it should be noted that the authors did not specifically measured the PROS length, rather than, they used automatic segmentation programme embedded in the OCT instrument. The outer segment that was defined in this segmentation programme did not properly represent the PROS length. Moreover, all of these three studies focused on children with anisometropic amblyopia in which the axial lengths of both eyes significantly differs. Surely, this can be adjusted by several statisticall tests. For this reason, to eliminate the effects of several contributing factors (axial length, age, sex etc.) on OCT measurements, only the strabismic amblyopic and fellow eyes were enrolled in the current study. The main limitation of this study is the lack of the PROS lengths prior to amblyopia treatment. We do not know whether the PROS length changes with treatment. Another limitation is that the measurements were performed manually. The superior and inferior borders (EZ and RPE) were set automatically by the programme (segmentation of all layers) in Spectralis OCT. Surely, a full automated image analysis programme for PROS length measurement like retinal nerve fiver layer may give more accurate results.

Conclusion

In conclusion, the amblyopic process in strabismus does not signficantly affect the PROS length. It is obvious that further investigations focused on this issue is required to detect the subtle changes in retinas of amblyopes.

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