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ORIGINAL RESEARCH

Retinal nerve fiber layer thickness in recovered and persistent amblyopia

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Purpose: To investigate, using optical coherence tomography (OCT), whether retinal nerve fiber layer thickness (RNFLT) is affected in amblyopic eyes.

Methods: Using OCT (Stratus OCT™ [Carl Zeiss, Dublin, CA]), the RNFLT was measured in 26 patients with persistent unilateral amblyopia and in 25 patients with recovered unilateral amblyopia. The RNFLT was compared between the affected and fellow eyes in patients with persistent amblyopia and in those with recovered amblyopia, and between the amblyopic eyes of patients with persistent amblyopia and the previously amblyopic eyes of patients with recovered amblyopia.

Results: In patients with persistent amblyopia and in those with recovered amblyopia, the affected eyes were significantly more hyperopic than the fellow eyes. The average (±standard deviation) RNFLT measured 105.5 ± 14.0 μm for the persistently amblyopic eyes; this value did not significantly differ from that of the fellow eyes (105.2 ± 13.0 μm) or the previously amblyopic eyes of recovered amblyopia (107.1 ± 11.7 μm). Also, logistic regression analysis adjusting for refraction showed no significant difference in the RNFLT between the persistently amblyopic eyes and the previously amblyopic eyes.

Conclusions: Our results indicate that there is no significant change in the RNFLT in amblyopic eyes.

Keywords: optical coherence tomography, retinal nerve fiber layer thickness, amblyopia

Introduction

Amblyopia is characterized by reduced visual acuity, in one or both eyes, which is caused by visual deprivation or abnormal binocular interaction during the development of vision.[1] The site responsible for amblyopic visual deficits has classically been thought to be in the visual cortex and the lateral geniculate nucleus (LGN).[2] The dysfunction of LGN in human amblyopia has recently been demonstrated.[3,4] Retinal involvement was once believed on the basis of neurophysiologic studies,[5] but subsequent studies have not always supported the involvement of the retina in amblyopia.[6] Recently, an optic disc anomaly in amblyopia has been demonstrated using fundus photographs.[7–9] Thus, whether or not amblyopia is associated with any structural change in the retina remains to be investigated.

Optical coherence tomography (OCT) has increasingly often and widely been used in ophthalmology practice.[10] It permits the noninvasive measurements of the peripapillary retinal nerve fiber layer thickness (RNFLT). The RNFLT, as measured by OCT, has been shown to correlate with visual function.[11] Several OCT

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measurements in children have been reported[12–14] and have been found to be acceptably reproducible.[15] The interocular asymmetry of RNFLT in 6-year-old children has been assessed, and the interocular average RNFLT has been found to be moderately correlated.[16] Therefore, the evaluation of the interocular asymmetry of RNFLT can be validated.

In this study, we used OCT in patients with persistent and recovered amblyopia. We sought to determine whether or not a change in RNFLT is associated with the persistence of amblyopia by examining these two groups of patients.

Materials and methods

Fifty-four patients with a history of unilateral amblyopia were enrolled in the study. All the patients had been treated for amblyopia. This treatment had included the correction of refractive errors and the patching of the sound eye or instillation of atropine in the sound eye. Patients enrolled in this study had amblyopia caused by strabismus, anisometropia, or both. Data from three patients were excluded from further analysis because of a low signal strength, poor image quality, or poor fixation during the measurements. Accordingly, we analyzed the data from 51 patients. These patients were divided into two groups: 52 eyes of 26 patients with persistent amblyopia (16 male and 10 female, whose ages ranged from 5 to 30 years (10.9 ± 6.3 years) when the images were taken) and 50 eyes of 25 patients who had recovered from amblyopia (6 male and 19 female, whose ages ranged from 5 to 35 years (8.4 ± 6.0 years). All patients underwent a complete eye examination, including cycloplegic refraction. The final best-corrected visual acuity (BCVA) of the amblyopic eye ranged from 20/200 to 20/30. The BCVA of the fellow eye of the patients with persistent amblyopia and the recovered amblyopic eye was equal to, or better than, 20/20. All these patients were followed up for more than 5 years to ascertain that the improvement in visual acuity had reached a plateau.

In each patient, the RNFLT was measured through a study of dilated pupils using the Stratus OCT™ (Carl Zeiss, Dublin, CA). Informed consent was obtained from each patient. The principles of the OCT have been described elsewhere.[10] All of the OCT scans were performed by an experienced operator blinded of the patient's identity and the results of any other tests. The fast RNFL algorithm was used to obtain the RNFLT measurements. Three images, each consisting of 256 A scans along a 3.4 mm-diameter circular ring around the optic disc, were acquired and were then averaged for analysis. Only scans with a signal strength of at least 6 were accepted.

SPSS 17.0J (SPSS Japan, Inc., Tokyo, Japan) was used to perform the statistical analysis. A paired *t*-test was used to assess the difference in parameters between amblyopic (previous or persistent) and fellow eyes in patients with persistent amblyopia and those with recovered amblyopia. An unpaired *t*-test was used to assess the differences in parameters between the amblyopic eyes of patients with persistent amblyopia and the previously amblyopic eyes of patients with recovered amblyopia. Logistic regression analysis was applied to adjust for the effect of refraction. *P* values of less than 0.05 were considered to be statistically significant.

Results

In patients with recovered amblyopia and those with persistent amblyopia, the affected eyes were significantly more hyperopic than the fellow eyes (Table 1). There was no significant difference in RNFLT between the affected and fellow eyes in each group. In addition, logistic regression analysis adjusting for refraction showed that there was no significant difference in RNFLT between the amblyopic eyes of patients with persistent amblyopia and the previously

Table 1 Comparison of refraction and retinal nerve fiber layer thickness

	Comparison between affected and contralateral eyes					
	Recovered amblyopia (50 eyes of 25 subjects)			**Persistent amblyopia (52 eyes of 26 subjects)**		
	Contralateral eye	**Affected eye**	***P****	**Contralateral eye**	**Affected eye**	***P****
Refraction (diopters)	1.725 (2.173)	3.365 (3.492)	0.002	1.499 (2.272)	3.468 (3.941)	0.003
Retinal nerve fiber layer thickness (μm)	104.39 (9.24)	107.13 (11.69)	0.201	105.16 (12.99)	105.48 (13.97)	0.477
Comparison between affected eyes of recovered and persistent amblyopia						
Refraction			$P = 0.965$			
Retinal nerve fiber layer thickness			$P = 0.565$			

Note: Data are shown as "mean (standard deviation)". Refraction: spherical equivalent values. *P* values are for comparison between affected and fellow eyes* (paired *t*-test) and between the affected eyes of recovered and persistent amblyopia (unpaired *t*-test).

amblyopic eyes of patients with recovered amblyopia ($P = 0.482$).

Discussion

In this study, we did not observe any significant difference in RNFLT between the affected and fellow eyes neither in patients with recovered amblyopia nor in those with persistent amblyopia. Our findings are in agreement with most of the previous OCT studies of amblyopia.[17–22] Also, our OCT measurements of the RNFLT in amblyopic eyes, around 100 μm, are generally in line with values published in previous reports of children.[12–14,22] On the other hand, Yen et al[23] reported that the RNFLT values of amblyopic eyes were significantly thicker than those of the fellow eyes in anisometropic amblyopia, but not in strabismic amblyopia. Similarly, Yoon et al[24] have shown a significantly thicker RNFLT in hyperopic anisometropic amblyopia. Kee et al[18] demonstrated that, although there was no difference in RNFLT between amblyopic and fellow eyes, the RNFLTs of amblyopic eyes were significantly thicker in anisometropic amblyopia than in strabismic amblyopia.

Axial length and refractive error have been shown to affect the measurements of RNFLT by OCT.[13] It has been demonstrated that RNFLT is positively correlated with refractive error, ie, RNFLT is thicker in more hyperopic eyes.[12] In this study, because the affected eyes were significantly more hyperopic than the fellow eyes in patients with recovered amblyopia and in those with persistent amblyopia, we might have overestimated the RNFLT in the affected eyes or underestimated that in the fellow eyes. The effects of refraction may, in part, explain our results that the RNFLT was slightly thicker for the affected eyes than for the fellow eyes in patients with recovered amblyopia and in those with persistent amblyopia. Nevertheless, logistic regression analysis showed that the association between RNFLT and the persistence of amblyopia remained insignificant after adjusting for refraction as a potential confounder. In addition, the change in RNFLT associated with refraction is quite small; the RNFLT only increased by approximately 1.671 μm for each diopter of hyperopia.[12] Although histological and functional changes in the LGN and visual cortex have been well established, the difference in RNFLT found between the amblyopic and fellow eyes is fairly small, even when there is a statistically significant difference.[23,24] Therefore, the amblyopic process does not seem to have a profound effect on the retina. Our finding will not change the current practice of amblyopia treatment, but it may have an implication on the future treatment targeting the site(s) affected by amblyopia.

Disclosure

The authors report no conflicts of interest in this work.

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