Introduction

Amblyopia is identified by a reduced best-corrected visual acuity (BCVA) in one or both eyes caused by an abnormal visual experience in the developing visual system without any organic abnormality of the globe.\(^1\) Although the eye is believed to be structurally normal in amblyopia, it has been well established that the anatomy and function of the visual cortex and lateral geniculate nucleus are changed by the visual deprivation of amblyopia.\(^2\) Some authors have elucidated the abnormal alterations of the optic nerve, ganglion cells, and nerve fiber layer of retina in amblyopia.\(^3\)

Optical coherence tomography (OCT) is a noninvasive technique for high-resolution cross-sectional tomographic imaging of the retina and optic nerve head.\(^4\) Although the retinal nerve fiber layer (RNFL) and macular thickness have been
studied by OCT in anisometropic and strabismic amblyopia, the results of these studies have been contradictory.\textsuperscript{5-10} Therefore, in this study, we compared the macular and peripapillary RNFL thicknesses of ambyopic (anisometropic and strabismic) and fellow eyes using OCT to reveal any differences. Additionally, we sought to determine the anatomical differences between these subtypes of amblyopia.

**PATIENT AND METHODS**

The study was performed at the strabismus unit of Nikookari Eye Hospital as a prospective cross-sectional descriptive study from 2009 to 2011. Patients aged between 6 and 18 years with a diagnosis of unilateral amblyopia (BCVA ranging from 20/40 to 20/400) were enrolled in the study. The informed consent forms were approved by the Ethics Committee of Tabriz University of Medical Sciences.

The patients were divided into two groups: those with pure strabismic amblyopia and those with pure anisometropic amblyopia. In the anisometropic group, the patients demonstrated no deviations in the cover test. The anisometropia in hyperopia, astigmatism, and myopia was regarded as 1, 1.5, and 3 diopters of difference, respectively. In the strabismic group, the patients had no anisometropia (based on the study’s criteria). The minimum angle of deviation manifested was 10 prism diopters in the cover test.

All cases underwent a comprehensive ophthalmic examination, including visual acuity, cycloplegic refraction, and slit-lamp and fundus examinations. Those cases with any ocular or neurologic disease or an inability to maintain a steady fixation behind the OCT camera were excluded from the study. In the anisometropic group, patients with myopia or hyperopia of more than 5 diopters in either eye or with more than a 1-mm difference in the axial length between the two eyes were excluded to reduce the effect of the refractive error on the measurement.

All OCT (Stratus OCT3; Carl Zeiss Meditec, Dublin, CA) measurements were performed by a single technician after full dilation of the pupil. A fast RNFL scan (three consecutive 360 degree circular scans with a diameter of 3.4 mm around the optic disc) was used. The OCT software calculated the average thickness from three samples. To measure the macular thickness, we used a macular scan consisting of six radial scans. Subsequently, the measurement was performed with a 6-mm diameter map.

Statistical analysis was performed by SPSS-16 software (SPSS, Inc., Chicago, IL). The pattern of distribution was evaluated by the Kolmogorov–Smirnov test, and the comparison of macular and RNFL thicknesses was performed by the paired samples \( t \) test. A \( P \) value less than .05 was considered statistically significant.

**RESULTS**

Twenty-five patients with monocular strabismic amblyopia and 25 with monocular anisometropic amblyopia were included. The mean age of the patients was 10 ± 3.1 years (range: 6 to 18 years) in the anisometropic group and 8.9 ± 3.7 years (range: 6 to 18 years) in the strabismic group. The strabismic group comprised 22 esotropic and 3 exotropic patients (15 males and 10 females). The anisometropic group comprised 21 anisohyperopic and 4 anisomyopic patients (16 males and 9 females).

In the anisometropic group, the macular thickness of the amblyopic eyes was significantly greater than that of the fellow eyes. However, there was no significant difference in the RNFL thickness between amblyopic and fellow eyes in this group (Table 1). However, in strabismic group, we found no significant differences between amblyopic and fellow eyes in terms of the macular or peripapillary RNFL thickness (Table 1). Consequently, no significant differences were found between strabismic and anisometropic amblyopic eyes in terms of the macular or RNFL thickness (Table 2).

**DISCUSSION**

In this study, we observed a significant difference in the macular thickness between amblyopic and fellow eyes in anisometropic amblyopia. Our finding is in agreement with the study of Al-Haddad et al., who reported that central macular thickness was significantly increased in anisometropic amblyopia using the spectral-domain OCT.\textsuperscript{11} We measured 25 eyes with anisometropic amblyopia (21 with hyperopic and 4 with myopic anisometropia). Pang et al. showed that amblyopic children with unilateral high myopia tend to have a thicker fovea in the amblyopic eye than in the normal fellow eye.\textsuperscript{12} Huynh et al. reported a greater foveal thickness in patients with hyperopic anisometropia amblyopia.\textsuperscript{9} However, other studies have yielded inconsistent findings. Dickmann et al. measured 20 eyes with mixed anisometropic amblyopia.
(10 with myopic and 10 with hyperopic anisometropia) and reported no difference in macular thickness between the amblyopic and the fellow eyes. Yoon et al. studied 31 patients with hyperopic anisometropic amblyopia and obtained the same finding.

Although some authors reported that myopia, especially more than 5 diopters, was associated with a change in the macular thickness, we could not find any association between hyperopia and macular thickness in the literature. However, patients with myopia or hyperopia of more than 5 diopters in either eye or with more than a 1-mm difference in axial length between the two eyes were often excluded to reduce the effect of refractive error on this measurement. Twenty-one cases in the anisometropic group had hyperopic anisometropia.

Leone et al. proposed that the inadvertent measurement of a parafoveal eccentric point in amblyopia may be the cause of increased macular thickness. In our study, unsteady fixation was one of the exclusion criteria. The procedure of adjusting the scan placement was performed to observe off-centered scans in patients with steady fixations. Therefore, off-centered scans cannot be the cause of changes in the macular thickness.

Al-Haddad et al. reported that the interocular differences did not reach statistical significance in the control group of nonamblyopic anisometropia. Therefore, it seems that anisometropia and refractive error alone could not produce such a difference, and the amblyopia may be the major reason for the macular change.

In our study, the increase of macular thickness in amblyopic eyes was not significant in patients with strabismic amblyopia. This finding is consistent with other studies. Altintas et al. found no change in the macular thickness of patients with strabismic amblyopia. Quoc et al. reported similar findings for patients with strabismic amblyopia. On the other hand, Dickmann et al. reported that the only difference in thickness between eyes with strabismic amblyopia and fellow eyes appeared in the macula. Huynh et al. reported a greater foveal thickness in patients with strabismic amblyopia.

Our findings support Huynh et al.’s hypothesis of a thicker macula in amblyopia only in the anisometropic group. It has been proposed that an arrest in the normal postnatal changes in amblyopic eyes could affect the normal maturation of the macula, including the movement of Henle’s fibers away from the foveola, and could result in an increased foveal thickness, as measured by OCT. However, the interpretation of our results remains to be determined by future studies.

Liu et al. reported that some children with ametropic and anisometropic amblyopia who failed to achieve normal visual acuity after treatment showed a thicker macula on OCT examination. Therefore,
it seems that the macular involvement in anisometropic amblyopia can lead to resistance to therapy. We do not have a reliable history of amblyopia treatment among our patients. Further studies are needed to confirm the effect of macular changes on amblyopia treatment.

Our results indicate that there was no significant difference between amblyopic and fellow eyes in macular or peripapillary RNFL thickness in either strabismic or anisometropic amblyopia. In addition, most authors have reported similar findings in previous studies.\(^\text{17-19}\) Yoon et al. reported that OCT assessment yielded a significantly thicker RNFL thickness in patients with hyperopic anisometropic amblyopia.\(^\text{10}\) Kee et al. reported a significantly thicker RNFL in anisometropic amblyopia than in strabismic amblyopia.\(^\text{19}\) Although the average thickness of the peripapillary RNFL was greater in anisometropic than in strabismic amblyopia in our study, this difference was not statistically significant.

Refractive error has been shown to affect the measurement of RNFL thickness by OCT.\(^\text{20}\) It has been demonstrated that RNFL thickness is positively correlated with refractive error (RNFL is thicker in more hyperopic eyes).\(^\text{21}\) In our study, we did not enroll patients with myopia or hyperopia of more than 5 diopters in either eye to reduce the potential for this concern.

The most important limitation of our study was the small number of patients enrolled, precluding subgroup analysis based on the type of anisometropia and deviation. Another weakness of the current study was that there was no control group of patients with anisometropia or with strabismus without amblyopia.

Our findings indicate that the macula of anisometropic amblyopic eyes were significantly thicker than those of fellow eyes. The increases in the macular thickness of eyes with strabismic amblyopia were not significant. Furthermore, it was found that amblyopia did not impact the peripapillary RNFL thickness. Possible involvement of the retina in amblyopia is controversial. However, further studies are warranted to establish retinal changes in amblyopia and to determine whether retinal involvement has any effect on the response to amblyopia therapy.

REFERENCES