

Correlation between Retinal Nerve Fiber Layer Thickness by Optical Coherence Tomography and Perimetric Parameters in Optic Atrophy

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Purpose: To investigate the correlation between retinal nerve fiber layer (RNFL) thickness determined by optical coherence tomography (OCT) and visual field (VF) parameters in patients with optic atrophy.

Methods: This study was performed on 35 eyes of 28 patients with optic atrophy. RNFL thickness was measured by OCT (Carl Zeiss, Jena, Germany) and automated perimetry was performed using the Humphrey Field Analyzer (Carl Zeiss, Jena, Germany). The correlation between RNFL thickness and VF parameters was evaluated.

Results: Mean global RNFL thickness was $44.9 \pm 27.5 \mu\text{m}$ which was significantly correlated with mean deviation score on automated perimetry ($r=0.493$, $P=0.003$); however, no significant correlation was observed between visual field pattern standard deviation and the corresponding quadrantic RNFL thickness. In a similar manner, no significant association was found between visual acuity and RNLF thickness.

Conclusion: Mean global RNFL thickness as determined by OCT seems to be correlated with VF defect depth as represented by the mean deviation score on Humphrey VF testing. OCT may be used as an objective diagnostic tool in the evaluation of patients with optic atrophy.

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INTRODUCTION

The approach to the patient with optic atrophy may pose a diagnostic challenge; in certain cases it may be difficult to distinguish subtle or early optic nerve disease from normal variations. An accurate diagnosis is vital for timely treatment to prevent visual loss and avoid unnecessary ancillary procedures. Diagnostic tools employed for this purpose include fundus photography,¹ visual field (VF) analysis,²

laser polarimetry³ and optical coherence tomography (OCT).⁴⁻⁹

At present, VF evaluation remains the most common test in the approach to neuro-ophthalmologic disorders.¹ Each point in the VF reflects the visual characteristics of the corresponding point in the retina. Static threshold perimetry records visual function at each retinal location qualitatively and semi-quantitatively by measuring the weakest perceptible light spot.¹ Perimetry is subjective by nature

and requires patient cooperation for a considerable period of time. These drawbacks have led to seek objective methods to serve as alternative or supplementary diagnostic tools.

OCT is a non-invasive imaging technology with increasing applications in the evaluation of retinal and macular diseases, neuro-ophthalmologic disorders and glaucoma.^{4,6} OCT can quantitatively measure retinal nerve fiber layer (RNFL) thickness in a cross-sectional manner with relatively high accuracy.⁴

One may assume that reduced visual sensitivity in any given area of the VF should be proportionate to the amount of ganglion cell loss in the corresponding retinal area. It would be therefore reasonable to expect RNFL thickness to be correlated with the degree of VF loss. The aim of this study was to evaluate the correlation between RNFL thickness as measured by OCT and VF parameters as determined by Humphrey automated perimetry in patients with optic atrophy.

METHODS

This study includes consecutive patients with optic atrophy referred to our neuro-ophthalmology clinic in whom a diagnosis of optic atrophy was established by a neuro-ophthalmologist based on RNFL drop out and optic disc pallor. Inclusion criteria were loss of visual acuity or VF defect with relative afferent pupillary defect and color vision disturbance in the presence of normal intraocular pressure (11-17 mmHg), normal anterior segment examination and normal fovea. Exclusion criteria were history of previous ocular surgery, cataracts other than 2+ or less nuclear sclerosis, metamorphopsia on Amsler grid screening and any abnormality of the optic nerve head other than atrophy.

All subjects underwent a comprehensive ophthalmologic examination including best-corrected visual acuity (BCVA), color vision, anterior segment examination, intraocular pressure measurement, dilated funduscopy and VF examination. Perimetry was obtained by the Humphrey Field Analyzer (Carl Zeiss, Jena,

Germany) using static threshold strategy and the SITA-standard 24-II program. The VF was repeated within 2 weeks to confirm the abnormalities and the following parameters were recorded: type of defect,¹⁰ mean deviation and pattern standard deviation (PSD). Following perimetry, all eyes underwent peripapillary RNFL measurement using an OCT machine (OCT II, Carl Zeiss, Jena, Germany). External fixation was used and a circular 1.7 mm scan centered on the optic disc was obtained. Three of the best obtained scans were selected. OCT was repeated when the obtained scans were not appropriate due to poor focusing or inadequate centration. The patient was excluded if repeat scans were also unsatisfactory. Finally, the selected OCT scans were analyzed using the Average Retinal Nerve Fiber Layer Thickness Program. Mean RNFL thickness was recorded globally and separately for the superior, inferior, nasal and temporal quadrants.

Regression analysis was used to evaluate the correlation between mean deviation on Humphrey VFs and global RNFL thickness as well as between mean PSD in eyes with focal defects and the RNFL thickness of the corresponding quadrant of the retina as follows: inferior RNFL for superior scotomata, nasal and temporal RNFL for temporal and nasal VF defects respectively, and superior RNFL for inferior scotomata. In eyes with intermediate scotomata, the analysis was performed first for RNFL thickness of the relevant quadrants individually and then for their mean values: for instance in the case of a superotemporal scotoma, the analysis was performed once for RNFL thickness in the inferior and nasal quadrants, and another time for average RNFL thickness of the inferior and nasal quadrants.

RESULTS

Overall, 35 eyes of 28 patients including 15 (53.6%) female and 13 (46.4%) male subjects with mean age of 41.3 ± 18.5 (range 7-70) years were evaluated. No patient was excluded due to inadequate fixation or poor cooperation. Causes of optic atrophy included old (more

than 3 months) anterior ischemic optic neuropathy in 18 eyes (51.4%), traumatic optic neuropathy in 11 eyes (31.4%), and brain tumors, anterior optic neuritis and optic nerve tumors, each in 2 eyes (5.7%). VF defects included generalized depression in 22 eyes (62.6%), arcuate defects in 2 eyes (5.7%), altitudinal defect in one eye (2.9%) and single or multiple localized defects in the superior and inferior visual fields in other cases.

Mean deviation on VF was -27.04 ± 6.08 decibels (dB) and mean global RNFL thickness was 44.9 ± 27.5 μm (table 1). Regression analysis revealed a significant correlation between these two indices with a linear coefficient of 0.49 ($P=0.003$). This correlation was not found between mean PSD in focal defects and RNFL thickness in the corresponding quadrant(s). Similarly no correlation was observed between BCVA and RNFL thickness. Receiver-operating characteristic (ROC) curve on the basis of mean deviation on VF and mean global RNFL thickness disclosed sensitivity and specificity of 100% at a cut-off point of 114.9 μm for mean RNFL thickness.

Table 1 Visual field and OCT parameters

	Mean \pm Standard deviation
Visual field	
Mean deviation	-27.04 ± 6.08 dB
Pattern standard deviation	7.23 ± 2.37 dB
RNFL thickness on OCT (μm)	
Global	44.90 ± 27.53 μm
Superior quadrant	60.80 ± 43.33 μm
Nasal quadrant	38.20 ± 35.20 μm
Temporal quadrant	33.94 ± 34.20 μm
Inferior quadrant	46.90 ± 36.56 μm

RNFL, retinal nerve fiber layer; OCT, optical coherence tomography; dB, decibel; μm , micron.

DISCUSSION

Many neuro-ophthalmologic disorders present with optic atrophy. Timely and accurate diagnosis is very important especially when the condition is not severe, the defect is segmental, or when an underlying organic pathology is suspected in a patient with psychological or functional disorders. Perimetry remains the

gold standard for evaluation of optic nerve disorders.^{1,2} VF testing is a qualitative or semi-quantitative, and subjective method which may be of limited clinical value in patients with poor reliability. Therefore, other ancillary diagnostic tests should complement VF examination.

OCT is an accurate and reproducible method for measuring RNFL thickness.^{4,9} Jones et al⁷ reported that RNFL thickness can be evaluated by OCT with high reproducibility either globally or for every quadrant; however sectorial scans or clock hour measurements have low reproducibility. Monterio et al⁸ compared OCT and VF findings in 37 patients with band optic nerve atrophy and normal controls. They found that mean global RNFL thickness or RNFL thickness in the temporal or nasal quadrants has the highest sensitivity for detecting band atrophy, however 30-degree sectors have low sensitivity in this regard. Schuman et al⁶ demonstrated that circular OCT scans using external fixation are highly reproducible. They reported minor inter- and intra-subject variability in patients whose visual acuity was light perception or less and therefore internal fixation was impossible.

Kanamori¹¹ compared OCT and Goldmann perimetric findings in patients with chiasmal lesions and bitemporal hemianopia, and found that VF defects (based on target size) are correlated with RNFL thickness on OCT. The authors concluded that OCT can be used to determine band atrophy of the optic nerve. By evaluating mean RNFL thickness in patients with dominant optic atrophy, Kim et al⁹ demonstrated mean RNFL thickness to be significantly and symmetrically lower in both temporal quadrants as compared to other areas and concluded that OCT can help in the diagnosis of suspected cases. In 2002, Williams et al⁵ compared OCT and VF findings in glaucoma patients to evaluate the role of OCT in the early diagnosis of glaucoma. Although they found that OCT is able to discriminate patients with VF defects, its application for screening purposes needs improvement in reproducibility and quality. With the advent of new high quality OCT devices, this purpose has been

achievable such that in 2006 Sihota et al¹² reported that RNFL thickness measurements by Stratus OCT can identify early glaucoma.

The present study revealed that mean deviation on Humphrey VF has significant linear correlation with global RNFL thickness on OCT; however there was no correlation between mean PSD in focal defects with mean RNFL thickness of the corresponding quadrants. The reason may be that the scale of quadrant RNFL thickness may be too large to demonstrate small differences between adjacent points or foci. We also failed to notice any correlation between visual acuity and RNFL thickness. This finding indicates that neuro-ophthalmologic diseases may not affect macular nerve fibers, therefore no direct correlation may be observed between central visual acuity and the severity of VF defect. With the correlation between mean global RNFL on OCT and mean deviation on Humphrey VF, the ROC curve drawn between these two variables showed that when RNFL thickness decreases to less than 114.9 μm , causes of RNFL drop out such as optic atrophy should be investigated. The main limitation of our study was the relatively small sample size which was due to stringent exclusion criteria.

In conclusion, with generalized optic atrophy or abnormal mean deviation on VF testing, OCT may be used as an objective diagnostic method with high accuracy to verify optic atrophy. This may be particularly advantageous in borderline cases or patients suspected of nonorganic visual loss.

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