IS THERE A RELATIONSHIP BETWEEN VISUAL FIELD DEFECTS AND RETINAL NERVE FIBER LOSS IN GLAUCOMA?

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Abstract

Elevated intraocular pressure, visual field defects and optic disc changes characterize primary open-angle glaucoma. The relationship between retinal nerve fiber layer (RNFL) attenuation and visual field loss, both in absolute and proportionate terms is equivocal. For this reason, the present study evaluated the relationship between visual field loss and RNFL attenuation in a group of glaucomatous patients. The sample comprised 70 eyes with primary open-angle glaucoma. The visual field was examined with the Humphrey Field Analyzer using Program 30-2. The RNFL was studied with the Nerve Fiber Analyzer. For each visual field, the reduction in sensitivity in dB was expressed in proportionate terms. The retinal nerve fiber thickness (in μm), was also expressed in proportionate terms. In the earliest stages of the disease process, retinal nerve fiber attenuation was proportionately greater than visual field loss. This result suggests that RNFL evaluation may be more appropriate than visual field examination for the early detection of primary open-angle glaucoma. In the advanced phases, visual field loss seemed to be more extensive than RNFL attention.

Introduction

Elevated intraocular pressure, visual field defects and optic disc changes characterize primary open-angle glaucoma. However, these three signs are not always present simultaneously. Many studies have investigated the early signs of glaucoma. It has been suggested that thinning of the retinal nerve fiber layer (RNFL) precedes any functional loss, particularly that of visual field loss measured by conventional automated perimetry[1-3]. However, it is equivocal as to whether the earliest signs of damage are anatomical or functional in origin. The outcome can be influenced by many factors such as the sensitivity of the examination technique, the inter-individual difference among patients, or the stage of the disease process[4-6].

Statistically significant correlations have been reported between visual field loss and RNFL thinning in glaucoma[7-11]. However, it is not known whether, once the

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back

glaucomatous optic neuropathy commences, if there is a direct relationship between nerve fiber attenuation and visual field loss. The aim of the study, therefore, was to compare visual field loss and RNFL thinning in a group of glaucomatous eyes.

Material and methods

Seventy eyes of 37 patients, 20 females and 17 males, with primary open-angle glaucoma were examined. The mean age of the patients was 59.21 ± 13.86 years (ranging from 28-79 years). The visual acuity ranged from 0.7-1.0, with a mean value of 0.84. The intraocular pressure under therapy ranged from 14-22 mmHg, with a mean value of 17.4 mmHg. The visual fields were examined using the Humphrey Field Analyzer Program 30-2. The RNFL was examined with the Retinal Nerve Fiber Analyzer.

For each visual field, the percentage residual sensitivity was calculated by the formula: (A+B): 100 = A:X, where A is the sum in dB of the measured sensitivity at each stimulus location, B is the sum in dB of the reduction in sensitivity at each location as represented by the total deviation, and X represents the residual sensitivity expressed as a percentage. The percentage reduction in sensitivity, Y, was calculated as = 100-X.

For the RNFL, as measured by the NFA, the percentage of average residual thickness was calculated by the formula: A: 75 = X:100, where A is the measured average thickness of the RNFL, 75 is the normal average thickness value for the RNFL as obtained by our previous studies in normals, X represents the percentage average residual thickness. The percentage average reduction in the RNFL thickness, Y, was calculated as = 100-X.

Linear regression test was carried out between the mean deviation (MD) for the visual field and the average thickness of the RNFL. The same statistical procedure was used between the percentage reduction of the visual field and the percentage reduction of the RNFL thickness.

Results

Due to the low reliability of some visual field examinations and to some doubtful RNFL measurements, we excluded 17 eyes from the study, so that the final number was 53 glaucomatous eyes.

The linear regression test between the MD (expressed in dB), and the average thickness of the RNFL (in μm), for the 53 glaucomatous eyes was statistically significant ($p<0.033$). These data confirmed previous studies concerning the presence of a correlation between visual field loss and RNFL damage. The linear regression between the percentage reduction in sensitivity and the percentage reduction in RNFL thickness in the 53 glaucomatous eyes was not statistically significant ($p<0.364$). This latter finding was surprising given the correlation between MD and RNFL, when expressed in decibels and microns, respectively

We decided to analyze each individual patient and obtained two subgroups from our 53 glaucomatous eyes: a first subgroup, 27 eyes, with a MD <6dB and a second subgroup, 23 eyes, with an MD >6dB. In the first subgroup, the percentage reduction of RNFL average thickness was definitely greater than the percentage reduction of

perimetric sensitivity. Linear regression between these two parameters was statistically significant ($p<0.029$). In the second subgroup, the percentage reduction of perimetric sensitivity was always equal to or greater than the percentage reduction of RNFL average thickness. However, linear regression between these two parameters was not significant ($p<0.573$). The results from these two subgroups are very important. They may indicate that, in the first phase of the disease (MD <6dB), RNFL damage is predominant and more serious than visual field loss; in the following phases of the disease, RNFL damage and visual field loss are either similar or visual field loss is more pronounced.

Discussion

It is difficult to relate morphological changes in the RNFL to functional abnormalities, such as visual field defects. The measurement of the differential light threshold is an accepted procedure with well-defined normal values. However, the technology for the derivation of RNFL thickness is still in its infancy. Different methods have been used to study RNFL and great inter-individual variation has been found in normal subjects[2,4,6,8].

Glaucoma patients have a thinner RNFL than normals[12,13] and a correlation between RNFL thinning and visual field defects has already been reported. The relationship between neural capacity, as derived by high pass resolution perimetry, and RNFL thickness is different between primary open-angle glaucoma and normal-tension glaucoma[14]. A better correlation is found in the presence of diffuse rather than localized glaucomatous visual field defects[13,15]. Only the RNFL thickness in the lower quadrant correlates with the perimetric index MD in glaucoma patients[7]. In the present study, we found a statistically significant correlation between the average thickness of the RNFL and the perimetric index MD. In an attempt to find a better way to correlate anatomical damage and functional loss, we correlated the percentage thickness reduction of the RNFL with the percentage reduction in perimetric sensitivity. To undertake such a calculation, we had to use an arbitrary normal value for the average thickness of the RNFL. Our previous experiences suggested that 75 μm was a reasonable value for the average RNFL thickness in normals. The adoption of such a value may introduce a bias in our results. RNFL thickness exhibits considerable inter-individual variation in normals, so the large standard deviation has to be taken into account. RNFL thickness may depend on the individual anatomy, and changes with age.

In our study, we observed a statistically significant correlation between percentage RNFL reduction and percentage reduction in sensitivity in a subgroup of glaucoma patients with a perimetric mean deviation of up to 6dB. This group exhibited early visual field loss and yet the RNFL attenuation was constantly large, suggesting that fiber damage was predominant in the earliest phase of the glaucomatous process. In the subgroup with a mean deviation over 6dB, the correlation was not statistically significant. However, we noted that the percentage visual field damage was always greater than percentage RNFL attention. These results may indicate that, in the first phase of the disease, a proportionately large number of damaged fibers are necessary to produce a small visual field defect. In the advanced stage of the disease process, the relationship between field loss and RNFL thinning is more complex.

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