HIGH-PASS RESOLUTION NEURAL CAPACITY AND RETINAL NERVE FIBER LAYER THICKNESS IN GLAUCOMA

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Abstract

The neural capacity (NC) of high-pass resolution perimetry (HRP) was compared to the retinal nerve fiber layer thickness measured with the GDx Nerve Fiber Analyzer in 74 patients with either ocular hypertension or primary open-angle glaucoma at various stages of severity. A statistically significant correlation was found between the NC and the GDx ellipse average, the total polar integral, and ‘the number’ (linear regression analysis, p<0.05). A low NC is usually associated with a thinning of the nerve fiber layer.

Introduction

At present, high-pass resolution perimetry (HRP) is the only perimetric technique that allows the user to estimate the structural damage in glaucoma and neurological disease¹,². This is because of the relationship between the spatial separation of functional ganglion cells and the resolution threshold. The HRP neural capacity is an index of the number of functional retinocortical neural channels relative to the average age-corrected normal³,⁴. Estimation of the structural damage is based on a few studies, but clear demonstration in vivo is still lacking due to the difficulty of determining the extent of the damage⁵.

In the last few years, new techniques have been proposed to study the retinal nerve fiber layer in glaucoma. The reliability and reproducibility of these techniques allows the user to document reduction in the thickness of retinal nerve fiber layer, not only in established glaucoma cases, but also in most patients with ocular hypertension and a normal visual field⁶-⁸.

In this study, we compared HRP neural capacity with the results obtained from the GDx Nerve Fiber Analyzer in patients with ocular hypertension and in those with various stages of primary open-angle glaucoma.

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Material and methods

Eighteen patients with ocular hypertension and a normal visual field (mean age, 51.6 ± 10.8 years, minimum 28, maximum 64) and 56 patients with primary open-angle glaucoma (mean age, 64.4 ± 11.9 years, minimum 32 maximum 86) exhibiting optic nerve and visual field damage (stages 1 to 5 of the Glaucoma Staging System) were studied. Visual acuity was better than or equal to 0.6, and no other ocular diseases were present.

All subjects were examined with computerized automated perimetry (Humphrey 30-2 Full Threshold test) and with HRP (ring test; Ophthimus ring perimeter; HighTech Vision, Malmö; distributed by Nikon). Rings of different size are shown on a CTR screen until the threshold is reached. Targets have bright borders and dark cores with an average luminance identical to that of the background. Fifty stimulus locations are tested in the central visual field out to 30° eccentricity. Various visual field indices are calculated by the perimeter. The neural capacity (NC) is calculated using the relationship between the minimum angle of resolution (MAR) between retinal ganglion cells and the resolution threshold. This index supplies a good estimate of the percentage of active ganglion cells with respect to the age-corrected normal average.

Retinal nerve fiber layer thickness was measured using the GDx Nerve Fiber Analyzer (Laser Diagnostic Technologies, San Diego, CA). This is a scanning laser ophthalmoscope that measures the laser polarization retardation (diode laser 780 nm) due to birefringence of the nerve fiber layer. This retardation is assumed to be proportional to nerve fiber layer thickness. In this study an average of three images was used for each calculation. A circular band of ten pixels was placed concentrically to the optic nerve head at a distance of 1.75 nerve head diameters. A number of indices describing nerve fiber layer parameters are supplied automatically, and others can be customized and calculated on request.

In this study, we considered the following parameters: the ellipse average (EA), the average thickness along the ellipse surrounding the optic nerve; the total polar integral (TPI), the volume of the nerve fiber layer; and ‘the number’, an experimental index calculated from 215 parameters resulting from GDx scans. A value of over 70 is considered to be indicative of glaucomatous damage, while values of between 30 and 70 are considered to be suspicious of glaucoma.

One eye per patient was examined. When both eyes satisfied the inclusion criteria, the designated eye was selected at random. Linear regression analysis was used to document the relationship between the various GDx parameters and the HRP NC.

Results

The correlation between NC and ‘the number’ was $r = -0.368; p < 0.001$ (Fig. 1), that between NC and EA, $r = 0.315; p < 0.006$ (Fig. 2), and that between NC and TPI, $r = 0.242; p < 0.04$ (Fig. 3).
Fig. 1. Neural capacity against 'the number' (linear regression analysis).

\[ y = -0.368 (\pm 0.109) x + 60.147 (\pm 7.505) \]

Fig. 2. Neural capacity against ellipse average (linear regression analysis).

\[ y = 0.195 (\pm 0.07) x + 56.001 (\pm 4.751) \]

**Discussion**

We found weak correlations between NC and the nerve fiber layer parameters. With an increase in NC, there was an increase in the value of TPI and EA, and a reduction in the value of 'the number'. The nerve fiber volume decreased as the severity of the visual field defect increased. These findings indicate that a reduction of functioning retino-cortical channels is associated with a thinning of the nerve fiber layer, but the functional damage is weakly correlated to the anatomical damage.
Because of the great inter-individual variability in the diameter of the optic nerve head, it is not easy to establish the exact thickness of the nerve fiber layer on the basis of the percentage of functioning retinal ganglion cells. In some cases of very advanced visual field loss (stage 5 GSS), we found low values of NC to be associated with good nerve fiber layer thickness. This may be due to a particularly high individual number of optic fibers, but also to the fact that, in some cases, a portion of the fibers is not functioning. Nevertheless, our results support the hypothesis that the HRP neural capacity, to some extent, reflects glaucomatous structural damage. This is of interest with regard to the development of a structural staging system for glaucomatous damage.

References