MORPHOMETRIC PARAMETERS IN HIGH-TENSION AND NORMAL-TENSION GLAUCOMA
Correlation with visual field indices

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Abstract

The aim of the study was to determine the optic disc morphometric parameters in high-tension and normal-tension glaucoma by confocal scanning laser ophthalmoscopy and correlate the results with the visual field indices. One hundred and seventy-one glaucomatous patients were recruited for the study. For each patient, one eye was randomly chosen. Normal- and high-tension glaucomatous patients were classified using intraocular pressure (IOP): the normal-tension glaucoma group had an IOP of <22 mmHg during a diurnal tension curve, while high-tension glaucoma patients had an IOP of >21 mmHg in at least three measurements. All the patients were examined with the Humphrey Field Analyzer, Program 30-2, and the Heidelberg Retina Tomograph (HRT). The relationship of the HRT morphometric parameters to the visual field indices were explored by Pearson’s interclass correlation coefficient and a linear regression model. One hundred and twenty-four high-tension glaucoma eyes and 47 normal-pressure glaucoma eyes were assessed. No significant differences were found between high- and normal-tension glaucoma eyes for any morphometric parameters. Although different correlations were found between the HRT parameters and the visual field indices in the normal-tension and high-tension glaucoma, linear regression analysis showed that in both groups rim area was the most important predictor of mean deviation and corrected pattern standard deviation.

Introduction

The diagnosis and treatment of normal-tension glaucoma (NTG) has been equivocal since the disease was first described1. Some authors believe that the appearance of the optic nerve head (ONH) and of the visual field in patients with NTG is similar to that found in high-tension glaucoma (HTG)2-6. Other authors define NTG as a separate clinical entity characterized by typical glaucomatous ONH damage and visual field defects7-16.

Each author states that he has no proprietary interest in the development or marketing of any product or instrument mentioned in this article

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In order to address this question, we evaluated optic disc topography and determined the relationship between the ONH parameters and the visual field indices in patients with NTG and HTG.

Patients and methods

One hundred and seventy-one subjects were enrolled consecutively in the study between July 1995 and February 1996. Patients were recruited from the practices of two of the authors (SMD and FSM). All consecutive patients in whom reliable visual fields and adequate HRT (Heidelberg Engineering, Heidelberg, Germany) imaging were available, were used. One eye from each subject was selected on a random basis.

Patients were defined as having primary open-angle glaucoma if they had an abnormal visual field (as described below) and/or an abnormal ONH/retinal nerve fiber layer (RNFL) typical of glaucoma, an open angle at gonioscopy and no clinically apparent secondary cause for their glaucoma. All the patients were classified as having HTG or NTG on the basis of intraocular pressure (IOP). Patients with an IOP of >21 mmHg were defined as having HTG and those with an IOP of <22 mmHg after a diurnal tension curve from 8:00 a.m. to 8:00 p.m., and no history of high IOP, were defined as having NTG.

Patients were not excluded on the basis of visual acuity, media opacity, gender, age, race or refractive error. In the present study, no patient had a refractive error greater than -7.00 diopters (spherical equivalent). Patients with ocular/systemic disease potentially associated with optic neuropathy were excluded.

The optic disc of each eye studied was analyzed by HRT, running software version 1.11S. Using this confocal diode laser (670 nm), we obtained a series of 32 confocal images at consecutive focal planes, each 256×256 pixels in size that the computer then converted into a single topographic image. The depth of each topographic image series ranged from 0.5-4.0 mm in 0.5-mm increments, depending on individual differences in optic disc morphology. The field of each image was 10×10°. Three images were obtained for each eye and the mean of the three topographic image height measurements for each pixel location was calculated. Magnification error was corrected using keratometry values for each individual. The optic disc margin outline at the inner edge of the scleral ring, was drawn, under visual guidance, using a computer mouse system by a trained observer. The outline was verified by one of the authors and used to determine disc area. Then the program (Stereometric Measurements) calculated a number of predefined shape parameters. The HRT topographical parameters have been described in detail elsewhere. Both this methodology and the reproducibility/reliability of several of the shape measures have been described in detail elsewhere.

The visual fields of all the subjects were measured using the Humphrey Field Analyzer (HFA, Humphrey Instruments, San Leandro, CA), Program 30-2. Subjects were classified as having glaucoma if they had at least: a. three adjacent points reduced by 5dB with one of the points being reduced by at least 10dB; b. two adjacent points reduced by 10dB; or c. a 10dB difference across the nasal horizontal meridian in two adjacent points. None of the locations could be edge points except immediately above or below the nasal horizontal meridian. Only reliable fields were used, as determined by the reliability parameters when false positive responses were less than...
10%, false negative responses less than 10%, and fixation loss less than 3%. The last reliable visual field nearest the HRT measurements was chosen. Mean deviation (MD) and corrected pattern standard deviation (CPSD) were used for the study.

The data were analyzed using a descriptive analysis to find any difference between HRT parameters and visual field indices in the NTG and HTG groups. Student’s \( t \) test was used to compare morphological and perimetric results between the HTG and NTG groups when the distribution of the data was normal, the Mann-Whitney non-parametric test was used, when the distributions of the HTG and NTG data were not normal. A \( p \) value of <0.05 was considered to be statistically significant. Pearson’s interclass correlation coefficient (\( r \)) was used to assess the magnitude of correlation between two variables. A linear regression model was used to determine the independent contribution of variables included in the model.

**Results**

The 171 eyes were classified into two groups: 124 subjects had HTG and 47 NTG. The distribution of the data was normal, so Student’s \( t \) test was used to compare data between groups. The mean age ± standard deviation (SD) of patients with HTG was 64.02 ± 12.01 years, while patients with NTG had a mean age of 64.19 ± 11.31 years. These differences were not statistically significant. No significant difference was found between HTG and NTG for refraction (-0.74 ± 2.85 diopters and -1.01 ± 3.11 diopters, respectively (mean ± SD)) or for visual field indices.

Student’s \( t \) test revealed no significant differences between HTG and NTG for the following HRT parameters: disc area, cup area (CA), cup/disc area ratio (CDR), rim area (RA), cup volume, rim volume (RV), mean cup depth (MCD), maximum cup depth, cup shape measure (CSM), high variation contour, mean retinal nerve fiber layer thickness, retinal nerve fiber layer cross-sectional area.

In the HTG group, MD was significantly correlated to RA (\( r = 0.35 \)) and CSM (\( r = -0.37 \)) with a \( p \) value of less than 0.001, and to CA (\( r = -0.22 \)), RV (\( r = 0.27 \)) and MCD (\( r = -0.23 \)) with a \( p \) value of less than 0.01, while CPSD was significantly (\( p<0.001 \)) correlated to RA (\( r = -0.44 \)), RV (\( r = -0.33 \)) and CSM (\( r = 0.31 \)).

In the NTG group, MD was significantly (\( p<0.001 \)) correlated to RA (\( r = 0.54 \)), and to CDR (\( r = -0.39 \)), RV (\( r = 0.4 \)) and CSM (\( r = -0.41 \)) with a \( p \) value of less than 0.01, while CPSD was significantly (\( p<0.001 \)) correlated to RA (\( r = -0.44 \)) only.

Because of the several reasonable correlations between HRT parameters and MD and CPSD, a multiple linear regression model was used to determine the independent contribution of these parameters to detect glaucomatous ONHs. In the HTG group, RA was the most important predictor of MD (\( \beta = 5.02, \) standard error = 1.21, \( p<0.001 \)) and of CPSD (\( \beta = 3.94, \) standard error = 0.73, \( p<0.001 \)). Also, in the NTG group, RA was the most important predictor of MD (\( \beta = 7.46, \) standard error = 1.78, \( p<0.001 \)). The linear regression model was not applied to find the most important predictor of CPSD because only one correlation was found. In both groups, the second most important predictor of MD was CSM.
Discussion

It is easy to speculate that cases with NTG tend to be found by their disc appearance; in this study, no difference for any HRT parameters was found between NTG and HTG.

Many studies of NTG have described the characteristic visual field damage in these patients, and in many comparisons with HTG visual field loss have been reported\cite{1,3,5-8,13}. Few studies have correlated the optic disc morphometric parameters to the visual field. Using the same confocal laser scanning system, Edi et al. found different correlations between HRT parameters and MD in HTG and in NTG\cite{25}; indeed, in HTG, RNFLcsa was significantly correlated with global MD, while in NTG, RA was significantly correlated with MD\cite{25}. Correlation was strongest when sector analysis was undertaken. The correlation was stronger in the NTG group and could be explained on the basis that the visual field was more localized in NTG and more diffuse in HTG.

In this study, we found several correlations between the HRT parameters and the visual field indices, but the most interesting result was that, in both groups using a multiple linear regression model to determine the independent contribution of these parameters, the most important predictor of MD was RA.

In view of the fact that we cannot report any differences between glaucoma patients when the pressure level is the only factor used to separate them, the work of some investigators to divide primary open-angle glaucoma into subgroups based on appearance of the optic disc, might be more rewarding\cite{26}.

References

Optic discs and visual field in HTG and NTG