Influence of Myopic Disc Shape on the Diagnostic Precision of the Heidelberg Retina Tomograph

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Purpose: To investigate the diagnostic capability of a glaucoma diagnostic classification program for the Heidelberg Retina Tomograph (HRT) in eyes with myopic disc shapes.

Methods: Sixty-six normal subjects (66 eyes) and 78 open-angle glaucoma patients (78 eyes) were enrolled. The eyes were divided into two groups; those eyes with myopic and those with nonmyopic disc shapes. The classification was based on clinical judgment made after the examination of stereophotographs of the discs without considering the refractive errors. The agreement between the classification program and the clinical diagnosis was evaluated for sensitivity, specificity, and diagnostic precision. The influence of the disc shape on the HRT topographic parameters was evaluated.

Results: The sensitivity, specificity, and diagnostic precision of the HRT were 83%, 95%, and 89% in eyes with nonmyopic disc shapes, but 71%, 96%, and 83% in those with myopic disc shapes. Rim volume, height variation contour, mean retinal fiber nerve layer (RNFL) thickness, and RNFL cross-section area were significantly larger in eyes with myopic disc shapes than in eyes with nonmyopic discs, regardless of the clinical diagnosis.

Conclusions: The classification program should be modified to take into account the myopic disc shape in order to improve its capability to make more accurate diagnosis of glaucoma possible. **Jpn J Ophthalmol 1999;43:392–397**

Key Words: Classification program, Heidelberg Retina Tomograph, myopic disc.

Introduction

The assessment of optic disc damage is important in the diagnosis of patients with glaucoma, as the changes may precede the detection of visual field defects in early glaucoma.[1–4] The Heidelberg retina tomograph (HRT) has been developed to provide objective and quantitative values of the three-dimensional topographic structure of the optic disc by confocal scanning laser ophthalmoscopy. Several investigators have reported on the reliability and the usefulness of the data obtained by optic disc topography.[5–10]

Mikelberg et al[11] reported that patients with glaucomatous visual field defect can be detected with the HRT by using a combination of the disc parameters. Lester et al[12] proposed a discriminate analysis formula to identify early glaucoma, using the values obtained by HRT of the cup shape measure corrected for age, rim volume, and height variation contour. This discriminate analysis formula has been used to classify the optic disc as normal or glaucomatous.[12–15]

The HRT formula may be less accurate in detecting early glaucoma in eyes with myopic disc changes.[13,14] This is important, as the prevalence of primary open-angle glaucoma (POAG) or normal tension glaucoma (NTG) is significantly higher in

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myopic eyes than in emmetropic eyes,[16–20] and the proportion of myopic refraction is greater in the Japanese than White populations.[21]

In this study, we investigated the influence of the myopic disc shape on the diagnostic capability of the discriminate analysis formula used with HRT.

Materials and Methods

Subjects

Sixty-six normal subjects and 78 patients with glaucoma were enrolled in this study. All subjects were selected from the outpatient clinics of the Department of Ophthalmology of Nihon University School of Medicine, the University of Tokyo School of Medicine, and the Yoshikawa Eye Clinic. The subjects had to have a visual acuity of 0.8 or better, no evidence of media opacity, and no history of intraocular surgery. Only 1 eye of each subject was chosen for the study.

Normal subjects had normal findings on ocular examination, a normal visual field, no family history of glaucoma, no history of ocular or neurologic disease, no history of diabetes or other systemic diseases, and no history of the use of any medications known to affect the intraocular pressure or the visual field. In addition, these normal subjects satisfied the following criteria: (1) a glaucoma hemifield test "within normal limits" and a corrected pattern standard deviation within the 95% normal limits measured with the 30-2 program of the Humphrey field analyzer; and (2) a mean defect $\leq$2 dB and corrected loss variance $\leq$4 dB determined by the G-1 program of the Octopus automated perimeter.

The open-angle glaucoma patients were determined to have open angles without peripheral anterior synechia, no history of ocular or intracranial diseases to account for the visual field defect or the appearance of the disc or the intraocular pressure, and no history of use of any medication that affects the intraocular pressure. In addition, the patients had reproducible glaucomatous visual field defect consisting of at least a 5 dB depression in a cluster of three or more locations along the course of the arcuate nerve fiber bundles, as confirmed on examination with the 30-2 program of the Humphrey visual field analyzer or the G-1 program of the Octopus automated perimeter (fixation loss $<$20%, false-positive or false-negative responses $<$20%). Subjects with glaucoma were enrolled without consideration of the highest intraocular pressure value, and their visual field defects had to be between stage 2 and stage 5 by Aulhorn's classification.

All subjects were classified into two groups by 4 investigators (NK, MS, SM, and MA), who independently based their decisions on the appearance of the optic disc in stereophotographs. The investigators were not informed of the clinical status of the subjects. Myopic discs were defined as tilted (obliquely implanted) with temporal crescents of peripapillary chorioretinal atrophy. Refractive errors were not considered. Nonmyopic discs could have various shapes including (1) focal ischemic, (2) senile sclerotic appearance, (3) generalized enlargement of the cup, and (4) nonclassifiable but not with a myopic disc appearance.[22] When there was a difference in the classification by the four investigators, the disc was classified as a nonmyopic disc.

This study followed the tenets of the Declaration of Helsinki, and informed consent was obtained from all participants after the purpose of the study had been explained.

HRT Analysis

The three-dimensional topographic analysis of the optic disc was done with the HRT. One eye of each subject was dilated with 0.5% tropicamide and three images were obtained. A mean topographic image was constructed with the software version 2.01 of the HRT. The contour line of the optic disc margin, at the inner edge of the scleral ring (Elsching's ring), was drawn on the HRT screen using a computer mouse by three experienced operators (YY, KY, and SK) while viewing the stereoscopic disc photographs. The operating software provided with the HRT calculates 13 predefined topographic parameters. The reference plane was automatically set at 50 μm below the mean peripapillary vertical height along the temporal sector between 350° and 356° based on the tilted disc system.

Mean topographic images with standard deviation less than 40 μm were used in the present study. The discriminate analysis formula developed by Mikelberg et al[11] and Lester et al[12] considered three HRT parameters: the rim volume (RV), the cup shape measure (CSM) corrected for age, and the height variation contour (HVC). The normal disc was differentiated from the abnormal disc using these parameters according to the following formulas:

$$\text{Corrected CSM (corCSM)} = \text{CSM} + [0.001981 + (50 - \text{Age})]$$

$$A = (RV \times 1.951) + (HVC \times 30.125) + (-28.521 \times \text{corCSM}) - 10.083$$

$$B = (RV \times -9.039) + (HVC \times 37.370) + (-15.442 \times \text{corCSM}) - 7.4211$$

If A > B, the disc was classified as normal. If A < B, the disc was classified as glaucomatous.

The sensitivity, the specificity, and the diagnostic precision (diagnostic precision is the proportion with or without the disease identified by the test) were determined for the entire group and for the two subsets, which were segregated by disc shape.

For statistical analysis, the Mann-Whitney *U*-test was used to compare the normal and glaucomatous eyes for each topographic parameter tested.

To determine the reliability of the data obtained by the topographic measurements, the optic disc contour line was marked independently by the three operators for 11 selected mean topographic images, using the mouse. The interoperators' coefficient of variation for the disc area was 2.7%.

Results

The sensitivity, specificity, and diagnostic precision calculated by the HRT discriminate analysis formula was 79%, 95%, and 87%, respectively, for the discs of all subjects. The sensitivity, specificity and diagnostic precision were 83%, 95%, and 89% for eyes with nonmyopic discs, and 71%, 96%, and 83% for eyes with myopic discs. There was a trend for the sensitivity to decrease in eyes with myopic discs compared to those with nonmyopic discs (Table 1).

The difference in the stage of the visual field defect between the eyes with myopic discs and those with nonmyopic disc shapes was not statistically significant in both the glaucomatous subjects and in total subjects (Table 2).

The clinical factors and topographic parameters of the 66 normal eyes and 78 eyes of glaucomatous subjects are shown in Table 3. There were significant differences between the normal and glaucoma groups in the clinical factors and topographic parameters except for age, HVC, and reference height (Tables 4 and 5). In the normal subjects, those with myopic discs were significantly younger and had significantly larger RV, HVC, mean retinal fiber nerve layer (RNFL) thickness, and RNFL cross-section area than those with nonmyopic discs. In the glaucoma subjects, patients with myopic discs were significantly younger, and had significantly larger refractive errors, axial length, cup volume, RV, HVC, mean RNFL thickness, and RNFL cross-section area than the patients with nonmyopic discs.

Table 1. Capacity of Heidelberg Retina Tomograph (HRT) to Detect Glaucomatous Disc Change

	Clinical Diagnosis		SS (%)	SP (%)	DP (%)
	Normal	Glaucoma			
All Subjects					
Normal HRT	63	16	79	95	87
Abnormal HRT	3	63			
Nonmyopic disc					
Normal HRT	40	9	83	95	89
Abnormal HRT	2	45			
Myopic disc					
Normal HRT	23	7	71	96	83
Abnormal HRT	1	17			

SS: sensitivity, SP: specificity, DP: diagnostic precision.

Table 2. Relationship Between Optic Disc Shape and Visual Field Defect

Stage*	0	II	III	IV	V
Myopic	42	16	19	12	7
Nonmyopic	24	11	6	2	5

Proportion of visual field defects is not significantly different between total subjects (χ^2 = 4.58, P = .333) and glaucoma subjects χ^2 = 4.25, P = .236).
*Aulhorn classification.

Discussion

The sensitivity, specificity, and diagnostic precision determined by the HRT discriminate analysis formula were 79%, 95%, and 87% for the entire group of subjects. These values are better than those reported previously.[12–15] The present results confirmed that the HRT discriminate analysis formula was capable of detecting the glaucomatous optic disc changes in Japanese, who have a higher incidence of myopia.[21]

In terms of the optic disc shapes, there was a trend for the sensitivity to decrease in eyes with myopic discs compared to those with nonmyopic discs. To differentiate normal subjects from glaucomatous subjects, the HRT formula applied three useful parameters, cup shape, RV, and HVC. In the present study, there were statistically significant differences in the cup shape measure and the RV between the normal and the glaucoma groups. However, no difference in the HVC contour was found. The HVC was defined as the difference in height between the most elevated and the most depressed points of the contour line. This corresponds to the differences in the RNFL thickness in glaucomatous eyes. In the HRT software version 2.01, the reference plane was automatically set at 50 μm posterior to the mean peripapillary retinal height along the contour line at the temporal sector between 350° and 356°. It may be possible that this selection of the reference plane ac-

Table 3. Comparisons of Clinical Factors and Heidelberg Retina Tomograph Topographic Parameters Between Eyes With Myopic Discs and Those With Nonmyopic Discs in All Subjects

Factors/Parameters	All Subjects		P Value*
	Normal	Glaucomatous	
Number of eyes	66	78	
Age (years)	58.6 ± 13.3	57.7 ± 12.3	.295
Refraction (D)	−0.51 ± 2.37	−2.30 ± 3.61	.040
Axial-length (mm)	23.1 ± 1.6	24.3 ± 1.7	.000
Disc Area (mm^2)	1.91 ± 0.35	2.21 ± 0.54	.000
Cup Area (mm^2)	0.39 ± 0.23	1.21 ± 0.62	.000
Rim Area (mm^2)	1.51 ± 0.30	0.99 ± 0.38	.000
Cup/disc area ratio	0.20 ± 0.11	0.53 ± 0.20	.000
Cup volume (mm^3)	0.08 ± 0.07	0.36 ± 0.27	.000
Rim volume (mm^3)	0.41 ± 0.12	0.23 ± 0.15	.000
Mean cup depth (mm)	0.19 ± 0.08	0.32 ± 0.11	.000
Maximum cup depth (mm)	0.56 ± 0.21	0.69 ± 0.19	.000
Cup shape measure	−0.22 ± 0.06	−0.07 ± 0.08	.000
Height variation contour (mm)	0.41 ± 0.09	0.39 ± 0.11	.154
Mean RNFL thickness (mm)	0.26 ± 0.08	0.18 ± 0.08	.000
RNFL cross-section area (mm^2)	1.29 ± 0.36	0.97 ± 0.44	.000
Reference height (mm)	0.34 ± 0.09	0.31 ± 0.10	.064

D: diopter, RNFL: retinal nerve fiber layer.
*Mann-Whitney *U*-test

counts for the decreased capability of the HRT program in eyes with myopic discs.

In myopic eyes, the enlargement of the posterior pole of the eye occurs corresponding to the increase in the axial length. The chorioretinal tissue shows stretching, atrophy, and degeneration. Because the optic disc is located on the nasal side of the eye, the temporal area of the optic disc is affected by the anatomical changes of myopia. The most characteristic shape of the myopic disc is that it is tilted from the nasal to the temporal side with the nasal margin elevated relative to the temporal margin. This shape is

Table 4. Comparisons of Clinical Factors and Heidelberg Retina Tomograph Topographic Parameters Between Eyes With Myopic Discs and Those With Nonmyopic Discs in Normal Subjects

Factors/Parameters	Normal Subjects		P Value*
	Myopic	Nonmyopic	
Number of eyes	24	42	
Age (years)	52.0 ± 13.5	62.4 ± 11.6	.000
Refraction (D)	−1.55 ± 2.48	0.08 ± 2.08	.121
Axial-length (mm)	23.4 ± 1.7	22.9 ± 1.4	.085
Disc area (mm^2)	1.87 ± 0.32	1.93 ± 0.37	.377
Cup area (mm^2)	0.36 ± 0.23	0.41 ± 0.23	.119
Rim area (mm^2)	1.51 ± 0.28	1.52 ± 0.30	.416
Cup/disc area ratio	0.19 ± 0.10	0.21 ± 0.11	.181
Cup volume (mm^3)	0.06 ± 0.07	0.09 ± 0.07	.118
Rim volume (mm^3)	0.48 ± 0.11	0.38 ± 0.12	.001
Mean cup depth (mm)	0.19 ± 0.07	0.18 ± 0.08	.375
Maximum cup depth (mm)	0.58 ± 0.16	0.54 ± 0.23	.195
Cup shape measure	−0.23 ± 0.07	−0.22 ± 0.06	.120
Height variation contour (mm)	0.46 ± 0.09	0.38 ± 0.08	.000
Mean RNFL thickness (mm)	0.31 ± 0.07	0.24 ± 0.06	.000
RNFL cross-section area (mm^2)	1.49 ± 0.35	1.18 ± 0.32	.000
Reference height (mm)	0.36 ± 0.09	0.33 ± 0.09	.110

D: diopter, RNFL: retinal nerve fiber layer.
*Mann-Whitney *U*-test.

Jpn J Ophthalmol
Vol 43: 392–397, 1999

Table 5. Comparisons of Clinical Factors and Heidelberg Retina Tomograph Topographic Parameters Between Eyes With Myopic Discs and Those With Nonmyopic Discs in Glaucoma Subjects

Factors/Parameters	Glaucoma Subjects Myopic	Glaucoma Subjects Nonmyopic	*P* value*
Number of eyes	24	54	
Age (years)	53.0 ± 12.4	59.8 ± 11.5	.009
Refraction (D)	−5.51 ± 3.78	−0.86 ± 2.35	.000
Axial-length (mm)	25.8 ± 1.8	23.7 ± 1.1	.000
Disc area (mm^2)	2.16 ± 0.57	2.23 ± 0.52	.294
Cup area (mm^2)	1.07 ± 0.58	0.27 ± 0.63	.143
Rim area (mm^2)	1.09 ± 0.58	0.95 ± 0.35	.082
Cup/disc area ratio	0.48 ± 0.22	0.55 ± 0.18	.111
Cup volume (mm^3)	0.27 ± 0.21	0.40 ± 0.28	.036
Rim volume (mm^3)	0.29 ± 0.19	0.20 ± 0.13	.034
Mean cup depth (mm)	0.29 ± 0.12	0.33 ± 0.10	.086
Maximum cup depth (mm)	0.63 ± 0.21	0.72 ± 0.17	.060
Cup shape measure	−0.08 ± 0.08	−0.07 ± 0.08	.319
Height variation contour (mm)	0.43 ± 0.12	0.37 ± 0.10	.017
Mean RNFL thickness (mm)	0.21 ± 0.08	0.17 ± 0.08	.041
RNFL cross-section area (mm^2)	1.13 ± 0.48	0.89 ± 0.40	.030
Reference height (mm)	0.33 ± 0.13	0.30 ± 0.08	.236

D: diopter, RNFL: retinal nerve fiber layer.
*Mann-Whitney *U*-test.

called an oblique disc.[24,25] In the present study, myopic discs were classified as oblique discs with temporal crescents, regardless of the refractive error. In the HRT software version 2.01, because the nasal margin of the oblique disc appears elevated to the vitreous surface compared with the reference plane, the HVC increases the volume above the reference plane in the contour line, ie, RV might be overestimated regardless of the refractive error. This hypothesis can be applied to normal subjects whose HVC and RV are significantly larger in eyes with myopic discs than in those with nonmyopic discs, although there were no significant differences in refractive errors and axial length.

The RNFL thickness is defined as the elevation of the retinal surface along the contour line above the reference plane. In eyes with oblique discs, the RNFL thickness is overestimated on the nasal disc margin because the reference plane is located posteriorly. These findings suggest that eyes with myopic discs show significantly thicker RNFL and larger RNFL cross-section areas compared with those containing nonmyopic discs.

In glaucoma patients, eyes with myopic discs had a significantly larger RV, HVC, mean RNFL thickness, and RNFL cross-section areas than those with nonmyopic discs. These findings agree with the findings of Broadway et al.[13] There is a significant relationship between the topographic parameters for the optic disc and glaucomatous visual field defects.[26,27] In the present study, there was no difference in visual field defects between eyes with myopic discs and those with nonmyopic discs. The significant differences in topographic parameters of the optic disc in glaucoma subjects showed the same disparity in the reference plane for the optic disc shape as found in normal subjects.

In the glaucoma subjects, eyes with myopic discs showed significantly smaller cup volume than those with nonmyopic discs. It is known that the depression of the optic disc margin, ie, undermining, is a characteristic change of glaucomatous discs. It has been reported that eyes with high myopia have thinner lamina cribrosa than nonmyopic eyes and show a stretched sclera because of the enlargement of the axial length. Therefore, even these eyes that may have advanced visual field defects show steep undermining with glaucoma.[28,29] One might hypothesize that the increase in axial length and the thinning of the lamina cribrosa make the cup volume of the eyes with myopic discs significantly smaller than those with nonmyopic discs.

The present study demonstrated that the HRT formula has the capability to detect glaucomatous optic disc changes in eyes with nonmyopic discs. However, in order to improve the predictive capability for glaucoma diagnosis, the HRT discriminate analysis formula should be modified to adjust for the myopic disc shape, which is prevalent among the Japanese.

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