A Comparison of Optic Nerve Head Topography in Primary Open-angle Glaucoma and Normal-tension Glaucoma in Korean

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We investigated whether there is any difference in optic nerve head topography between primary open-angle glaucoma (POAG) and normal-tension glaucoma (NTG) in Koreans. Twenty-three eyes of 23 POAG and 20 eyes of 20 NTG Korean patients closely matched for mean deviation of automated static threshold perimetry (Humphrey Field Analyzer, program C30-2) were enrolled. The patients’ mean age was 51.5 ± 11.7 years in POAG and 55.1 ± 10.6 years in NTG; the average mean deviation was -5.47 ± 1.84 dB in POAG and -6.45 ± 3.69 dB in NTG. Mean age and mean deviation were not statistically different between the two groups. Heidelberg Retina Tomograph was used to obtain topographic measurements of disc area, rim area, cup volume, cup-to-disc area ratio, mean cup depth, maximum cup depth, and cup shape measure. Disc area and cup volume were significantly larger in NTG than in POAG (p < 0.01, p = 0.03, respectively, Wilcoxon rank sum test). Other variables were not significantly different between the two groups. There was significant negative correlation between cup volume and rim area only in POAG (r = -0.725, p < 0.01, Spearman correlation analysis). These results suggest that the larger cup volume in NTG than in POAG may be influenced rather by larger optic disc in NTG not by smaller neuroretinal rim.

Key words: disc area, normal-tension glaucoma, optic nerve head topography, primary open-angle glaucoma

INTRODUCTION

Optic nerve head topography has been reported to be either different\(^1\)\(^^2\) or similar\(^3\)\(^^4\) between eyes with primary open-angle glaucoma (POAG) and normal-tension glaucoma (NTG). Differences in the pattern of glaucomatous optic nerve head damage may indicate the dissimilar pathogenesis of disc damage in these two clinical entities.

Confocal scanning laser tomography, a newly-developed method, allows highly reproducible measurements of optic nerve head configuration\(^5\)\(^6\)\(^7\)\(^8\). Until recently, to the best of our knowledge, there has been no report of comparing optic nerve head topography by confocal scanning laser tomography between POAG and NTG. Using confocal scanning laser tomography, we investigated whether there is any difference in optic nerve head topography between eyes with NTG and POAG matched for mean deviation of automated static threshold perimeter in Koreans.

MATERIALS AND METHODS

The inclusion criteria of POAG were as follows: (1) an intraocular pressure greater than 21 mmHg in
an eye without antiglaucoma medication, (2) characteristic glaucomatous optic nerve head damage, (3) glaucomatous visual field loss, and (4) open iridocorneal angle, and no abnormal chamber angle structure on gonioscopic examination. The inclusion criteria of NTG were as follows: (1) an intraocular pressure consistently less than 21 mmHg in an eye without antiglaucoma medication, (2) characteristic glaucomatous optic nerve head damage, (3) glaucomatous visual field loss, (4) no neuroradiologic evidence of optic nerve damage, and (5) open iridocorneal angle, and no abnormal chamber angle structure on gonioscopic examination. Glaucomatous visual field loss was detected with two consecutive fields by the Humphrey field analyzer 630 (Zeiss-Humphrey, Inc, San Leandro, CA), using program C30-2, standard, and full-threshold strategy as follows: (1) three or more adjacent points with P < 0.05 in a total deviation probability map, (2) two or more adjacent points with P < 0.01 in a total deviation probability map, or (3) a difference of > 10 decibels (dB) across the nasal horizontal meridian at two or more adjacent points.

Patients were excluded if the spherical equivalent of refractive error was not between -6 and +6 diopeters, or if an ocular disease other than glaucoma was present. Only one eye of patients with bilateral disease was randomly selected and enrolled in the study. A patient was excluded if there was advanced visual field loss with mean deviation of static threshold perimetry (Humphrey Field Analyzer, program C30-2) of more than -10.0 dB. All patients gave their informed consent prior to their inclusion in the study.

Twenty-three eyes of 23 Korean POAG patients and 20 eyes of 20 Korean NTG patients which met the above criteria and matched for mean deviation were enrolled.

Morphometric analysis was performed using a confocal scanning laser tomograph, the Heidelberg Retina Tomograph (HRT, version 1.11, Heidelberg Engineering, Heidelberg, Germany). The mean topographic image from triple measurements of the optic nerve head based on three 10 × 10-degree measurements was used for the analysis. The standard reference plane was used for all measurements. The contour line of the optic disc was drawn to the inner margin of the scleral rim. Measured topographic parameters of optic nerve head were disc area, rim area, cup volume, cup-to-disc area ratio, mean cup depth, maximum cup depth, and cup shape measure.

Each variable was compared between the two groups using the Wilcoxon rank sum test. In each group, cup volume, rim area, and maximum cup depth were analysed for correlation, using the Spearman correlation analysis.

**RESULTS**

The mean age of patients with POAG was 51.5 years (range, 28 to 73 years), and of those with NTG was 55.1 years (range, 37 to 69 years). The mean age of patients with NTG was slightly greater than that of patients with POAG, but the difference between the two groups was not significant (p = 0.27). Nor was there a statistically significant difference between the two groups in mean deviation of automated static threshold perimetry (p = 0.50) (Table 1).

Disc area was significantly larger in NTG than in POAG (p < 0.01) and cup volume was significantly greater in NTG than in POAG (p = 0.03). With

<table>
<thead>
<tr>
<th>Table 1. Patient demographics</th>
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<tr>
<td><strong>POAG</strong></td>
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<tr>
<td>number of eyes</td>
</tr>
<tr>
<td>age (years)</td>
</tr>
<tr>
<td>male : female</td>
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<tr>
<td>spherical equivalent (diopters)</td>
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<tr>
<td>intraocular pressure (mmHg)</td>
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<td>mean deviation in visual field (dB)</td>
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*: Wilcoxon rank sum test, POAG: primary open-angle glaucoma, NTG: normal-tension glaucoma
borderline statistical significance, cup-to-disc area ratio was larger in NTG than in POAG (p = 0.07) and the cup shape measure was less negative in NTG than in POAG (p = 0.06). Other variables including rim area were not significantly different between the two groups (Table 2).

There were significant negative correlations between cup volume and rim area only in POAG (r = -0.725, p < 0.01). A positive correlation between cup volume and maximum cup depth was identified both in POAG (r = 0.558, p = 0.006) and NTG (r = 0.672, p = 0.001). The correlation between cup volume and rim area was significant only in POAG, while the correlation between cup volume and maximum cup depth of each group was similar (Table 3).

**DISCUSSION**

Although many approaches have been done to determine whether there are differences in nerve head topography between POAG and NTG cases, disc size has been compared in only a few reports. Tuulonen and Airaksinen reported that large discs were more frequent in eyes with low-tension glaucoma. Burk et al. also noted similar results concerning larger disc area in normotensive discs compared to hypertensive discs. In the normal population, the size of the optic disc varies considerably, while the amount of neuronal tissue being relatively less variable. Normal eyes with a larger optic disc may show more cupping and eyes with a smaller optic disc may show less cupping. Our results showed that eyes with NTG have a larger cup volume and a disc area than eyes with POAG. In NTG, a larger cup volume may be caused by a larger optic disc. Although statistically insignificant, our results show that eyes with NTG have a larger cup-to-disc area ratio than eyes with POAG on low p-value (p=0.07).

Under matching for degree of visual field loss between the two groups, eyes with NTG have a larger cup volume than eyes with POAG. These findings support previous reports describing disproportionately greater cupping compared with comparable visual field loss in patients with normal tension glaucoma.

During enrollment, we excluded high myopes severe than -6 diopeter because the horizontal tilt of the optic nerve head in such cases may induce a bias in optic nerve head analysis. There was no significant difference in spherical equivalent between the two groups in our study.

The mean age of patients with NTG was slightly greater than those with POAG in this study, even though age distribution between the two groups was
not significantly different.

There were some opinions that eyeball and scleral canal size tend to decrease with aging.\textsuperscript{13,14} It was therefore unlikely that the larger optic disc seen in NTG cases was influenced by the age difference between the two groups. If above opinions are accepted and the mean age of the two groups in our study were exactly the same, the difference in optic disc size would be more significant and stronger.

In this study, the female proportion was higher in NTG than in POAG. If we consider, however, the previous reports that women's optic discs are smaller than those of men,\textsuperscript{14,15} the higher female proportion in NTG of this study may not affect the result of a larger optic disc in NTG.

Several studies have demonstrated that cupping in NTG is more likely to be broadly sloping.\textsuperscript{2,16} However, our results showed that cup shape measure indicating the slope was larger in NTG than in POAG with borderline significance which was a different finding from the previous reports. The correlation between rim area and cup volume in NTG is weaker than in POAG. Our findings indicate that the morphologic contour of the optic nerve head is similar except for disc size and cup size in both groups, which have similar visual field loss. It can be postulated that the greater disc cupping in NTG is probably due to a larger disc, because the rim area in both groups is not significantly different.

A large optic disc in NTG can be interpreted as follows: 1) selection bias, resulting in patients with large-cupped discs suggestive of glaucoma being more likely to undergo perimetry than those with ocular normotension and normal appearance of optic nerve head,\textsuperscript{14,17,18} 2) etiologically, the absolute size of an optic disc may be a risk factor in determining susceptibility to the development of glaucomatous damage at any given level of intraocular pressure.\textsuperscript{10,19}

A diagnosis of NTG is generally based on a large cup-to-disc ratio, the first sign, and this is consistent with selection bias of a large optic disc and high cup-to-disc ratio. However, the findings that in a larger disc there is greater displacement of laminar cribrosa at any given level of intraocular pressure\textsuperscript{19} and that diffusion distances of the laminar and prelaminar region in a larger disc are longer support the belief that a larger optic disc is more susceptible to damage at any given level of intraocular pressure.

In our study, the optic disc of Korean patients with NTG was larger than that of POAG patients and we think that the larger optic disc results in the greater cup volume seen in NTG patients. The more significant correlation between cup volume and rim area in POAG may be partially influenced by the relatively larger proportion of neuroretinal rim in the smaller optic disc. For this conclusion to be more definite, however, a case controlled study based on a larger population may be needed.

REFERENCES

A COMPARISON OF OPTIC NERVE HEAD TOPOGRAPHY IN POAG AND NTG