Relationship between Optic Nerve Head Parameters of Heidelberg Retina Tomograph and Visual Field Defects in Primary Open-Angle Glaucoma

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To investigate the correlation between optic nerve head configuration and visual field defects, optic nerve head analysis using confocal scanning laser tomography (Heidelberg Retina Tomograph, HRT) and automated static threshold perimetry using a Humphrey Field Analyzer (program C30-2) were performed on 81 eyes of 44 primary open-angle glaucoma (POAG) patients. The optic nerve head parameters—rim area, rim volume, mean retinal nerve fiber layer thickness, height variation contour, and third moment in contour were measured by HRT and were analyzed for correlation with visual field indices—mean deviation, and corrected pattern standard deviation. All optic nerve head parameters except HVC correlated significantly with the visual field indices; the highest correlation was between rim area and mean deviation \( r = 0.6172, p < 0.00001 \). The rim area of the superior and inferior quadrants correlated significantly with the visual field defects in corresponding sectors. Structural optic disc measurements by HRT correlated significantly with functional optic nerve head damage in POAG.

Key words: HRT, optic nerve head parameters, visual field indices

INTRODUCTION

In previous studies, it has been noted that there is a close relationship between the morphology of the optic nerve head and functional changes\(^{1-8}\) and that changes in the optic nerve head may precede detectable visual field loss in early glaucoma.\(^{10-14}\) Until recently, however, there has been no objective procedure for quantitative measurement of the disc structure, and judgment has been biased by the subjective view of the individual investigator. Early subtle disc changes have not been adequately identified by clinical estimates of the cup-disc ratio. For precise optic nerve head morphometry, a technique of measurement with high reproducibility and accuracy is required. The Heidelberg Retina Tomograph (HRT), employing a newly developed method of optic nerve head analysis, involving the confocal scanning laser tomograph technique, can provide objective and reproducible quantification of the contour of the optic nerve head.\(^{17,18}\)

We investigated the relationship between structural parameters of the optic nerve head and visual field defects in primary open-angle glaucoma measured by the HRT and the automated perimetry, respectively.

MATERIALS AND METHODS

The study comprised 81 eyes of 44 patients who were diagnosed as primary open-angle glaucoma.
OPTIC NERVE HEAD PARAMETERS

Criteria for inclusion were 1) intraocular pressure greater than 21 mmHg without medication, 2) glaucomatous changes of optic nerve head, 3) glaucomatous visual field defects. Twenty-nine patients were men and 15 were women; mean age was 46.2 ± 15.3 years.

Perimetry was performed using the Humphrey C30-2 program; visual field indices of mean deviation (MD) and corrected pattern standard deviation (CPSD) were obtained. The average MD and CPSD of the total number of eyes were -12.37 ± 9.29 dB and , 5.48 ± 4.29 dB, respectively.

Morphologic analysis of the optic nerve head was carried out using a confocal scanning laser tomograph, the Heidelberg Retina Tomograph (HRT, version 1.11, Heidelberg Engineering, Heidelberg, Germany). The optic nerve head parameters of rim area, rim volume, mean retinal nerve fiber layer thickness (RNFLT), height variation contour (HVC), and third moment in contour were obtained from a mean topographic image of three 15 x 15-degree measurements using the standard reference plane. Correlation between optic nerve head parameters and visual field indices was then analyzed.

To evaluate the regional relationship of optic nerve head parameters and visual field changes, total and pattern deviation plots of the visual field were subdivided into four sectors corresponding to the upper, lower, temporal, and nasal quadrant of the disc, respectively. Correlations between the superior quadrant of the disc and corresponding inferior visual field sectors in total and pattern deviation plots were analyzed, as were those between the inferior quadrant of the disc and corresponding superior visual field sectors in total and pattern deviation plots (Fig. 1).

For correlation between the morphological parameters of optic nerve head and visual field indices, Pearson correlation coefficients were used, and for comparison between the groups, one-way analysis of variance with Dunchan multiple comparisons was used.

RESULTS

With the exception of HVC, there was statistically significant correlation between each of the optic nerve head parameters and MD (Table 1, Figs. 2, 3, 4, and 5). There were also statistically significant correlations between some of the structural parameters (i.e. rim area, rim volume, mean RNFL thickness) and CPSD (Table 1, Figs. 6, 7, and 8). However, the correlations with CPSD were less strong than with MD. The strongest correlation was shown between rim area and MD (r = 0.6172, p < 0.00001).

The superior and inferior quadrant rim areas correlated significantly with the corresponding inferior and superior sectors in total and pattern
Table 1. Correlation between HRT parameters and visual field indices (n = 81 eyes)

<table>
<thead>
<tr>
<th>HRT parameters</th>
<th>Mean deviation</th>
<th>Corrected pattern standard deviation</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p</td>
</tr>
<tr>
<td>Rim area</td>
<td>0.6172</td>
<td>&lt; 0.00001</td>
</tr>
<tr>
<td>Rim volume</td>
<td>0.5701</td>
<td>&lt; 0.00001</td>
</tr>
<tr>
<td>Mean RNFLT</td>
<td>0.5353</td>
<td>&lt; 0.00001</td>
</tr>
<tr>
<td>HVC</td>
<td>-0.1065</td>
<td>0.3440</td>
</tr>
<tr>
<td>Third moment</td>
<td>-0.4012</td>
<td>0.00021</td>
</tr>
</tbody>
</table>

Fig. 2. Scatterplot shows a significant correlation between the rim area (x) and the mean deviation (y), (y = 12.9313x – 24.5678, r = 0.6172, p < 0.00001).

Fig. 4. Scatterplot shows a significant correlation between the mean retinal nerve fiber layer thickness (mRNFLT) (x) and the mean deviation (y), (y = 49.4242x – 18.9189, r = 0.5353, p < 0.00001).

Fig. 3. Scatterplot shows a significant correlation between the rim volume (x) and the mean deviation (y), (y = 40.4261x – 19.8309, r = 0.5701, p < 0.00001).

Fig. 5. Scatterplot shows a significant correlation between the third moment in contour (x) and the mean deviation (y), (y = -32.7742x – 14.2373, r = -0.4012, p < 0.00021).

Balazsi et al.\textsuperscript{2} reported that there was a significant correlation between neuroretinal rim area and overall retinal sensitivity. Airaksinen et al.\textsuperscript{3,4} reported that there was a good correlation between neuroretinal rim area and visual field indices such as mean defect, corrected loss variance and found the index for overall retinal sensitivity in visual field (mean defect) correlates better than that of localized visual field changes (corrected loss variance).

deviation plot of visual field, respectively, and the correlation was stronger with total than with pattern deviation (Table 2).

DISCUSSION

The relationship between structural optic nerve head damage and functional visual field defects has been investigated in several previous studies.
The results of this study were similar; there was statistically significant correlation between structural optic nerve head parameters and the indices of visual field defects. The strongest correlation was between rim area and MD, and this is consistent with the results of previous reports.\(^5\)\(^9\)

**Table 2. Correlation between quadrant rim area and corresponding field statistics**

<table>
<thead>
<tr>
<th>Combination for correlation</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD(<em>{\text{sup}}) - RA(</em>{\text{inf}})</td>
<td>0.5651</td>
<td>&lt; 0.00001</td>
</tr>
<tr>
<td>TD(<em>{\text{inf}}) - RA(</em>{\text{sup}})</td>
<td>0.6073</td>
<td>&lt; 0.00001</td>
</tr>
<tr>
<td>PD(<em>{\text{sup}}) - RA(</em>{\text{inf}})</td>
<td>0.2587</td>
<td>0.01972</td>
</tr>
<tr>
<td>PD(<em>{\text{inf}}) - RA(</em>{\text{sup}})</td>
<td>0.3200</td>
<td>0.00359</td>
</tr>
</tbody>
</table>

**TD\(_{\text{sup}}\):** sum of values in superior sector of total deviation plot corresponding to inferior quadrant of optic disc,

**TD\(_{\text{inf}}\):** sum of values in inferior sector of total deviation plot corresponding to superior quadrant of optic disc,

**PD\(_{\text{sup}}\):** sum of values in superior sector of pattern deviation plot corresponding to inferior quadrant of optic disc,

**PD\(_{\text{inf}}\):** sum of values in inferior sector of pattern deviation plot corresponding to superior quadrant of optic disc,

**RA\(_{\text{sup}}\):** rim area of superior quadrant,

**RA\(_{\text{inf}}\):** rim area of inferior quadrant

MD showed more significant correlation with structural optic nerve head parameters than did CPSPD. Rim area, rim volume, and mean RNFL thickness reflect the global status of the optic nerve head and are not sensitive to a localized abnormality. It is thus quite natural that these global optic nerve head parameters correlated better with MD, a global index of generalized field depression, and less closely with CPSPD, an index of localized visual field defects.

We also found statistically significant correlation between the superior quadrant rim area and the corresponding inferior sector of total and pattern deviation plots, and between the inferior quadrant rim area and the corresponding superior sector of visual field. This confirmed the regional relationship between optic nerve head parameters and visual field changes.\(^8\)

The correlation coefficients of this study are largely in accordance with those of previous reports.\(^6\)\(^8\) Our result that correlation coefficients are not so high (maximum \(r = 0.6172\)), but are statistically significant, may be influenced by the fact that changes in the optic nerve head may precede detectable visual field loss in early glaucoma.\(^{10-14}\)
For the evaluation and follow-up of glaucoma patients, a close comparison between optic nerve head parameters and visual field defects is required. Furthermore, regional comparison between superior or inferior rim area and inferior or superior field defect, respectively, may provide additional clues in the evaluation of HRT results.

REFERENCES


