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Alternative Method of Evaluating Visual Field Deterioration in Very Advanced Glaucomatous Eye by Microperimetry

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Purpose: To report an alternative method of evaluating visual field deterioration in very advanced glaucomatous eyes.

Methods: This prospective, comparative study included 24 eyes of 24 consecutive patients with very advanced glaucoma. The eyes were divided into two groups based on their visual field measurements by Goldmann perimetry: Group 1 had a central island with or without a detached temporal island (n = 13), and Group 2 had a central island with a temporal island connected by only a thin isthmus (n = 11). The size of the central island was determined by Goldmann perimetry, and microperimetry plots were determined around the disc margin. The angle formed between a line passing from the disc center to the "seen" points and a second line passing to the "not seen" points at the superior temporal or the inferior temporal sites was used for the analyses.

Results: The mean size of the island was 6.3 ± 1.9 in Group 1 and was 7.0 ± 2.0 in Group 2 ($P = .38$). The mean angle between the "seen" and "not seen" points in Groups 1 and 2 was 56.1 ± 6.9 and 76.1 ± 11.8, respectively ($P = .0002$). The reduction in the angle correlated with the visual field loss ($P = .018$), but the reduction in the size of the central island was not significantly associated with the visual field loss ($P = .29$).

Conclusion: Microperimetry may be an alternative method of evaluating advanced glaucoma. **Jpn J Ophthalmol 2003;47:178–181**

Key Words: Central island, Goldmann visual field, microperimetry, very advanced glaucoma.

Introduction

Glaucoma is the world's most common cause of irreversible blindness. It was estimated that by the year 2000, there would be 66.8 million glaucoma sufferers worldwide, and 10% would be blind bilaterally.[1] The prediction of visual field deterioration in terminal glaucomatous eyes is difficult, and sudden visual loss may occur even though the intraocular pressure seems to be well-controlled.[2,3] In general, visual field measurements by manual perimetry have shown that even in eyes with markedly reduced visual fields, a central island with an attached temporal island connected by a thin isthmus is still present.[4] This type of visual field worsens to either a central or a temporal island, and these islands progressively diminish in size with continued damage. These two islands can continue to decrease in size or the thin isthmus located between the two islands can be extinguished: at such times, the intraocular pressure (IOP) level is considered as not having been low enough. However, manual perimetry is subject to the influence of perimetrists, and an alternative method to detect visual field deterioration in terminal glaucomatous eyes may be of value.

The visual field deterioration in glaucomatous eyes is related to the corresponding retinal nerve fiber defects.[5] Microperimetry can disclose retinal nerve fiber layer defects, and the defect can be followed to the macular area when the microperimetry plots are placed

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consecutively along the temporal disc margin.[6] The aim of this study was to show a technique to evaluate the visual field deterioration in very advanced glaucomatous eyes using microperimetry.

Materials and Methods

This was a prospective, comparative clinical trial. Very advanced glaucomatous eyes were categorized into two groups based on the results of Goldmann visual field examination: Group 1 had only a central island or a central island with a detached temporal island, and Group 2 had a central island with a temporal island connected by only a thin isthmus. Eyes with only a temporal island were excluded because they were not able to fixate on the target. Corrective lenses were used, and all of the visual field within the central 30° was tested. No central island had a fixation-splitting defect.

Twenty-four consecutive, very advanced glaucomatous eyes of 24 patients were studied. All eyes were phakic, and their visual acuities were better than 0.5. Thirteen eyes were placed in Group 1 (mean age ± SD, 66.5 ± 11.8 years), and 11 eyes in group 2 (73.6 ± 2.9 years). The mean refractive error was 0.03 ± 2.19 diopters (range, −4.00 diopters to 4.75 diopters) in Group 1, and −1.09 ± 2.24 diopters (range, −5.00 diopters to 2.50 diopters) in Group 2 ($P = .29$). No tilted optic disc was observed in any of the 24 eyes. In Group 1, there were six round discs, two round discs with surrounding peripapillary atrophy, one round disc with a temporal gray thin crescent, two oval discs, one oval disc with surrounding peripapillary atrophy, and one oval disc with a temporal gray thin crescent. In Group 2, there were five round discs, three round discs with surrounding peripapillary atrophy, and three oval discs with a temporal gray thin crescent.

The distance between the I-4 isopter closest to the central island and the fixation point was recorded (Figure 1). The linear distance between the center of the central island and the nearest I-4 isopter was measured with a ruler and converted to degrees by multiplying the distance ×10/12 (10° Goldmann visual field = 12 mm).

Microperimetry was performed around the disc with a scanning laser ophthalmoscope (SLO; Rodenstock, Munich, Germany: stimulus size Goldmann 1, background 10 cd/m^2, stimulus intensity 0 dB, central fixation, manual tracking). The spots that were "seen" and "not seen" by the patient were automatically plotted on the microperimetry monitor as closed circles and open triangles, respectively. The

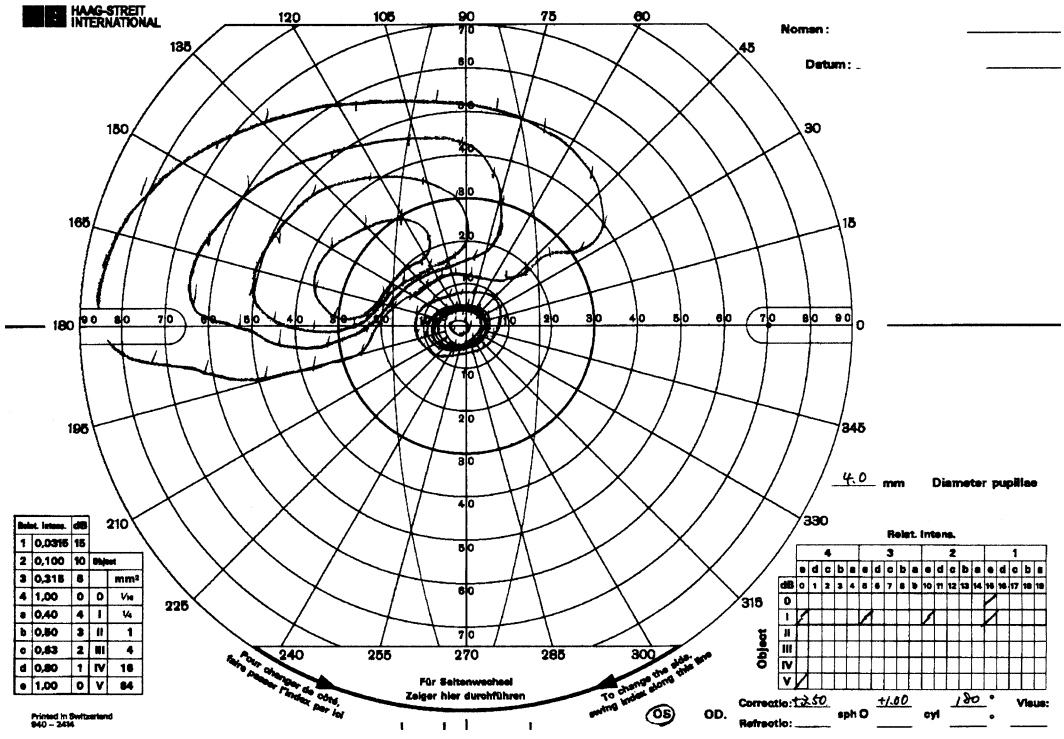

Figure 1. Goldmann visual field demonstrating a field with a central island and a detached temporal island. The size of the central island is 5°.

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center of the optic disc was determined by drawing a circle with a compass to include the entire inner margin of the peripapillary scleral ring.

The angle, formed by a line passing from the optic disc center to the "seen" area, and another line from the disc center to the "not seen" area at the superior temporal or the inferior temporal sites determined around the disc during microperimetry, was measured with a protractor (Figure 2).

All data are expressed as the mean ± SD. The differences between Groups 1 and 2 were analyzed using the Mann–Whitney *U*-test for the mean angle between the "seen" and "not seen" points and the mean size of the central island. Logistic regression was used for multiple comparisons. A level of $P < .05$ was accepted as statistically significant.

Results

The mean size of the central island determined by Goldmann perimetry was 6.3 ± 1.9 in Group 1 and 7.0 ± 2.0 in Group 2 ($P = .38$). The mean angle between the "seen" and "not seen" points in Groups 1 and 2 was 56.1 ± 6.9 and 76.1 ± 11.8, respectively ($P = .0002$; Table 1). The reduction in the angle was manifested as a decrease in the visual field ($P = .018$, odds ratio, 0.78; 95% confidence interval [CI]: 0.63, 0.96). The decrease in the size of the central island determined by Goldmann perimetry was not significantly associated with the visual field decrease ($P = .29$, odds ratio, 0.66; 95% CI: 0.30, 1.42: Figure 3).

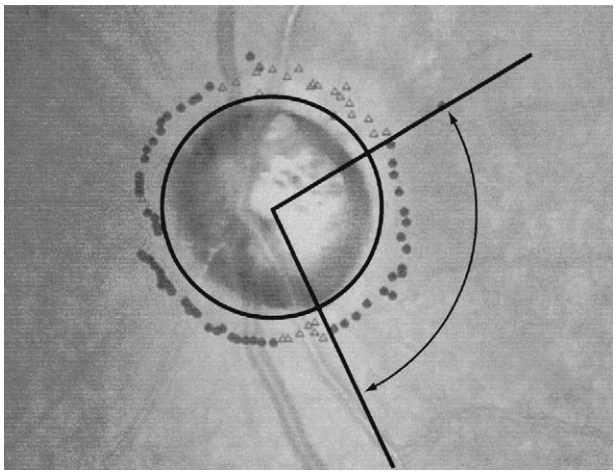

Figure 2. Microperimetric plots enclose the disc. The plots are placed outside the peripapillary choroidal atrophy if peripapillary choroidal atrophy exists. Closed circle and open triangle indicate "seen" and "not seen" spots, respectively. The disc center is determined by drawing a circle with a compass to include the entire inner margin of the peripapillary scleral ring. Two lines are drawn from the disc center to between the "seen" and "not seen" spots and the angle between the lines is taken.

Discussion

In advanced glaucomatous eyes, the diffuse loss of the retinal nerve fiber layer may be the result of an expansion of localized retinal nerve fiber layer defects.[7] The neuroretinal rim, which represents the location of most of the axons, is damaged predominantly in the lower and upper temporal disc sectors with relative sparing of the horizontal regions of the disc.[8]

A histological study[9] revealed that the percentage of optic nerve fibers lost in the temporal segment of eyes with visual fields consisting of a central island with an attached temporal island connected by a thin isthmus, or only a temporal island, was 18% and 2%, respectively, of that of normal eyes. This suggested that there were retinal nerve fibers on the temporal side of the disc that corresponded to the central island and the thin isthmus. Moreover, the study showed[9] that, at the terminal stage when the visual field consisted of only a central island with a detached temporal island, only the peripheral temporal and nasal fibers in the optic nerve remained. These fibers corresponded to the central and the temporal visual fields. This indicated that the retinal nerve fiber loss at the temporal site of the disc was still not complete after the thin isthmus was extinguished. The retinal nerve fiber loss at the temporal disc appears to be in progress even at the very advanced stage of glaucoma. Therefore, it is advisable to observe how wide the remaining retinal nerve fibers are at the temporal site of the disc to evaluate the visual field deterioration.

Microperimetric findings are closely correlated with structural findings and the retinal nerve fiber layer defects which are found before the use of scanning laser ophthalmoscopy.[6] The retinal nerve fiber layer bundle defects can be easily followed to the macular area when the microperimetry plots are placed consecutively along the temporal disc margin.[6] Thus, the "seen" plots are placed along or outside the margin of the retinal nerve fiber layer bundle defects, and the "not seen" plots are placed within retinal nerve fiber layer bundle defects. So the angle between the "seen" plots and the adjacent "not seen" plots may correspond to the width of the remaining retinal nerve fiber. Microperimetry appears to be able to detect the loss of the thin isthmus in very advanced glaucoma.

The temporal quadrant of the optic disc[10] is completely represented within the 30° visual field and has the advantage of being subjected to less pronounced artifacts from the large blood vessels than the upper, lower, and nasal quadrants.

Table 1. Data on Groups in Study

	Group 1 (n = 13)	Group 2 (n = 11)	*P*-Value
Age (yr)	66.5 ± 11.8	73.6 ± 2.9	.2
The degree of a central island on Goldmann perimetry (degree)	6.3 ± 1.9	7.0 ± 2.0	.38
The angle on microperimetry (degree)	56.1 ± 6.9	76.1 ± 11.8	.0002

Microperimetry is carried out under direct visualization of the fundus and may thus exclude any influence of the perimetrist. It is well known that the fixation of the eye on the fixation point is required during microperimetry.[11] Fortunately, the patients whose visual field has a central island have sufficient visual acuity to fixate on the fixation point. Thus, it appears that microperimetry can provide reliable data even in eyes with very advanced glaucoma.

It is well known that the automated central 10-2 threshold test is a good way to evaluate central visual field loss. However, this test may not be useful in detecting the decrease of the thin isthmus because the visual field that can be examined is not large enough to detect the decrease. Clinically, the loss of the thin isthmus is one of the important findings of visual field deterioration. We believe that microperimetry as well as the automated central 10-2 threshold test is useful for very advanced glaucoma.

There was not a clear-cut separation of the two groups in terms of the size of the angle between the "seen" and "not seen" points although a significant difference in the angle was observed. Anatomically, there are the accessory retinal nerve fiber bundles joining the main nerve fascicles from the temporal region of the human retina, and many small radial nerve bundles run externally between the main optic nerve fiber layer above and below the papillomacular bundle.[12] Microperimetry may detect these accessory bundles. However, additional and so far unknown causative factors have to be considered.

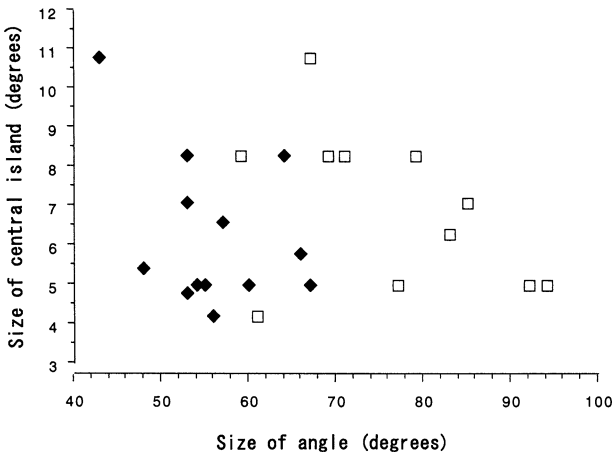

Figure 3. Scatterplot showing the relationship between the size of the central island determined by Goldmann perimetry and the angle determined by microperimetry. Closed diamond and open square indicate groups 1 and 2, respectively.

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