The Visual Performance and Metamorphopsia of Patients With Macular Holes

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**Background:** Most patients attain better visual acuity with the elimination of metamorphopsia after successful closure of a macular hole (MH) by vitrectomy.

**Objective:** To determine the presurgical visual function of eyes with an MH.

**Methods:** We examined 54 eyes of 51 patients with an idiopathic MH using the Amsler chart. We evaluated the types of subjective metamorphopsia and compared them with the clinical factors associated with MHs. In a prospective study, we performed a montage test on a separate group of 16 patients with unilateral idiopathic MHs. The patients were asked to choose, while viewing with their better eye, the computer-modified picture that best matched the unmodified image seen by the eye with the MH.

**Results:** From the results of the Amsler chart test, we divided the subjective changes into 2 types of metamorphopsia; of the 54 eyes, pincushion distortion (bowed toward the center) was found in 33 (61%), and unpatterned distortion (no specific pattern) was found in 21 (39%). Pincushion distortion was significantly associated with an MH of shorter duration (<6 months) \((P = .03)\) and an early stage (stage 2) of MH formation \((P = .02)\). A scotoma was hard to detect, and patients had difficulty describing their scotomata and distortions. In the montage test, patients with early MHs chose portraits modified with a pincushion type of distortion.

**Conclusions:** We found concentric pincushion metamorphopsia without subjective scotomata, which we suggest arises from an eccentric displacement of the photoreceptors. This accounts for the main characteristic of the visual performance of patients with idiopathic MHs.
PATIENTS AND METHODS

Between January 9, 1995, and December 19, 1997, we examined 54 eyes of 51 patients with an idiopathic MH using the Amsler chart. The research followed the tenets of the Declaration of Helsinki, informed consent was obtained from all participants, and the research was approved by the Departmental Review Board of Osaka University, Osaka, Japan. There were 16 men and 35 women whose mean ± SD age was 64.3 ± 6.5 years (range, 45-77 years). Fundus examinations were performed with a double aspheric indirect lens (Super Field; Volk Optical Inc, Mentor, Ohio) or a +78-diopter lens. When there was a question about the MH, microperimetry with a scanning laser ophthalmoscope was used to separate a pseudo-MH from a true full-thickness MH.10

Using Gass classification,16 there were 16 eyes with stage 2, 32 eyes with stage 3, and 6 eyes with stage 4 MHs. The duration of the MH, based on the patient's complaint, was 0.2 to 68 months (mean ± SD, 5.0 ± 9.1 months). The preoperative visual acuities ranged from 0.02 to 0.80.

We examined the results of the Amsler tests of the patients retrospectively, and evaluated the type of metamorphopsia. The type of metamorphopsia was compared with the duration of the MH, the stage of the MH, and the preoperative visual acuity. The Amsler chart examinations were carried out by the method recommended by Amsler,11 with a working distance of 0.3 m and the use of the same spectacle correction as used to test the reading acuity. Statistical analysis was performed using the χ2 test or the Fisher exact test.

Between January 12, 1998, and December 18, 1998, a separate group of 16 patients with unilateral idiopathic MHs (stage 2, 4 patients; stage 3, 10 patients; and stage 4, 2 patients) was studied to determine the visual perception of patients with an MH. The patients consisted of 4 men and 12 women (mean age, 66 years; range, 55-83 years). The duration of the MH was less than 6 months.

These patients were shown 4 photographs (10 × 13 cm) of a painting (Leonardo da Vinci's Mona Lisa), an unmodified picture and 3 that had been modified using computer software (Adobe Photoshop, Adobe Systems Inc, San Jose, Calif). While viewing the pictures with their unaffected eye, they were asked to select the portrait that best resembled the unmodified photograph seen by the affected eye.

RESULTS

From the results of the Amsler chart testing, the metamorphopsia was divided into 2 types. The first type was a pincushion distortion that made lines bowed toward the center (Figure 1, A), and the second was unpatterned metamorphopsia (Figure 1, B) that had no specific pattern. Of the 54 eyes, pincushion distortion was found in 33 (61%) and unpatterned metamorphopsia was found in 21 (39%). The Table shows the clinical features associated with the metamorphopsia as determined by Amsler chart testing. A pincushion distortion was significantly associated with an MH of shorter duration (<6 months) and with an earlier stage of MH (stage 2).

Because there was metamorphopsia in all of the patients, the central scotoma was usually difficult to delineate. Although most of the patients complained of loss of central vision, a scotoma or the disappearance of the fixation dot was hard to detect. The patients stated that when they gazed a little away from the central dot, it became easier to find the dot.

For the montage test, we modified the classic Mona Lisa portrait as follows: unmodified (Figure 2, A), a scotoma in the face (Figure 2, B), a pincushion distortion between the eyebrows (Figure 2, C), and a pincushion distortion with a small central area removed from the left eye (Figure 2, D). When viewed, all of the patients promptly denied seeing a central scotoma in Figure 2, B. The patients had difficulty describing their scotomata and distortions precisely; however, all patients selected the pincushion photograph as their perception with the eye with the MH (Figure 2, C and D). The difference in their description was in the location, size, or both of the pincushion lesion in the photographs. Two patients stated that the pincushion area appeared darker than other parts of the photograph.

COMMENT

Our results indicated that approximately 70% of the patients with a fresh MH (duration, ≤6 months) have metamorphopsia of the pincushion type. After a comprehensive study of the development of an MH, Gass15,16 established a classification of MHs, including the enlargement of retinal tissue resulting from a tangential traction of the vitreous. Smith and associates established a classification of MHs, including the enlargement of retinal tissue resulting from a tangential traction of the vitreous. Smith and associates17 also implied that the enlargement of the MH occurs without tissue loss around the macula. We have obtained evidence supporting the hypothesis by Gass, namely, an enlargement of the MH with displacement of the photoreceptors.

Can these observations on patients with an MH tell us anything about the retinal pathological characteristics? Assume a vertical line is imaged on the retina a few degrees from the fovea (Figure 3, A). If the line is to be perceived as bowing inward at the center, ie, a pincushion type of distortion, the center of the line must be closest to the fovea and the eccentric points of the line must fall on retinal points of increasing distance from the vertical meridian (Figure 3, B). For this to happen, the photoreceptors underlying the bowed line must be displaced (Figure 3, C) toward the vertical line shown in Figure 3, A, ie, from A through F to A’ through F’. If this movement of the photoreceptors occurs as by the traction of the retina, the image of the vertical line will fall on photoreceptors that will project the image as if it arose from stimulation of A through F, ie, a curved line bow-
ing toward the center. This would then imply that the retina would be displaced the most at the center and progressively less in the peripheral portion. This agrees well with the appearance of an MH as observed by indirect ophthalmoscopy.

The Amsler chart consists of a grid with vertical and horizontal lines with a fixation dot in the center. If we use a chart with only vertical lines and a fixation dot, we can represent the patient’s view (Figure 4). With an MH and the displacement of the retina, the brain’s image of straight lines is bent toward the center (the pincushion distortion) and the fixation dot is not seen by the patient with an MH (the central scotoma). This agrees well with the main characteristic of metamorphopsia in patients with an MH as a pincushion distortion with a defect of the central visual field. The central dot in the chart cannot be recognized because of the MH, although most patients can point out the central dot by eccentric fixation.

An MH is usually accompanied by a fluid cuff around the hole leading to functional damage to the retina surrounding the MH (Figure 5), and the patient’s perception will be more complicated than the anatomical alterations. The reason why some patients with an MH have metamorphopsia without any specific pattern (unpatterned) is probably due to the duration of the MH, namely, there may be more damage to the surrounding macular region with an MH of longer duration. In addition, we must also be aware of suppression in the brain as an adaptation to the metamorphopsia. If one assumes that the foveal cells can also become nonfunctioning in long-standing cases, then there would be a true foveal scotoma, rather than a remapping. Schuchard18 illustrated that scotomata frequently are “filled in” perceptually, and patients often report the filling in as distortions similar to the unpatterned distortions described herein. In this case, the distortion might be attributed to an active cortical phenomenon rather than simply an extension of the abnormal retinotopic projection hypothesis. The significant (P = .03) correlation between MH duration and characteristics of metamorphopsia can be caused by these reasons. Thus, patients with an MH of short duration who maintain good photoreceptor function with less adaptation or fill-in phenomenon in the brain are more sensitive to the pincushion distortion as a defect of the central visual field.

The enlargement of the hole without tissue loss around the macula, ie, retinal photoreceptor displacement, was also confirmed by Jensen and Larsen19 using differential perimetry. They reported a discrepancy in the size of the objective and subjective scotoma by differential perimetry using red and green filter glasses. They found that the subjective scotoma was concentric but considerably smaller than the objective scotoma in patients with symptoms for less than 6 months. In patients with a documented duration of symptoms for longer than 2 years, no discrepancy was found between the objective and subjective scotomata.

We also investigated the theoretical basis of the Watzke-Allen sign (Figure 6). Patients with a full-thickness MH can describe a complete break in a vertical

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**Figure 1.** Plots from the Amsler chart test. A, A pincushion distortion in a patient with an early macular hole. B, Unpatterned metamorphopsia in a patient with a long-standing macular hole.

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**Table 1.** Characteristics of Metamorphopsia by Amsler Chart Testing and Factors Associated With the MH

<table>
<thead>
<tr>
<th>MH Features</th>
<th>Pincushion (n = 33)</th>
<th>Unpatterned (n = 21)</th>
<th>P</th>
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<tr>
<td>Duration, mo</td>
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<td></td>
</tr>
<tr>
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<td>30</td>
<td>13</td>
<td>.03</td>
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<tr>
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<td>3</td>
<td>8</td>
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<td></td>
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<tr>
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<td>14</td>
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<td>.02</td>
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<td>3</td>
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<td>.20</td>
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<tr>
<td>≥20/100</td>
<td>14</td>
<td>13</td>
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</table>

*MH indicates macular hole; VA, visual acuity.*
Figure 2. Photographs of a Mona Lisa portrait modified by computer software. A, Normal portrait. B, Scotoma in a part of the face. C, Pincushion modification between the eyebrows using a pinch filter. D, Pincushion modification with deletion of a small area of the left eye mainly by a pinch filter. The original picture size is 10 × 13 cm. For a viewing distance of 0.3 m, the scotoma and pinch-filtered area are approximately 2° and 4°, respectively.
light beam, although this sign is not always reliable. Careful questioning of the patient during the testing is important to determine whether a complete break or a thinning of the light beam is being perceived. Because of the eccentric displacement of the macular retina, a slit light beam oriented perpendicularly and centered on the macular lesion is usually perceived as a thinning of the slit light beam by the brain. This phenomenon is another piece of evidence for the displacement of the photoreceptor.

We found concentric pincushion metamorphopsia without a subjective scotoma, which we suggest arises from an eccentric displacement of the retina. This accounts for the main characteristics of the visual performance of patients with an idiopathic MH.

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REFERENCES

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