New Visual Acuity Chart for Patients with Macular Hole

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PURPOSE. To evaluate the usefulness of a new multiple-letter visual acuity chart (MLAC) for the measurement of visual acuity in patients with macular hole.

METHODS. Visual acuity was measured using a standard visual acuity chart (Landolt rings, also referred to as C's) and with the MLAC in normal subjects and in patients with a cataract or a macular hole. The MLAC has 14 plates (45 × 45 cm), and on one plate, many Landolt C's were printed with the gaps pointing in the same direction and all of one size. The sizes of the letters and gaps were made to give equivalent visual acuities of 0.1, 0.15, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.2, 1.5, and 2.0. The spacing between the letters was 33.3% of the diameter of the C's. Each chart projected many C's onto the macular area (5° × 5°), which permitted the measurement of visual acuity at an extrafoveal point without the patient having to search for the extrafoveal point with the best acuity.

RESULTS. There was no difference in the acuity measurement determined with the standard chart and the MLAC in normal subjects and patients with cataracts. Twelve of 16 patients with open macular hole, however, demonstrated higher acuity measurement (more than two lines) on the MLAC than on the standard chart. The improvement of visual acuity measurement after successful macular hole surgery was significantly less with the MLAC than with the standard chart.

CONCLUSIONS. Our results suggest that the standard acuity chart, when administered before surgery, underestimates the patient’s potential visual acuity after surgery, whereas the MLAC provides a better estimate of the patient’s postoperative acuity. The MLAC can be a useful tool for measuring visual acuity in patients with macular hole.

METHODS

 Fifteen eyes of 15 normal subjects (58.6 ± 7.6 years), 15 eyes of 15 patients with cataract (68.8 ± 9.8 years), and 16 eyes of 16 patients with an idiopathic macular hole (65.4 ± 7.4 years) were studied. The visual acuity measurement using the standard acuity chart was 1.0 in all normal subjects. All 16 patients with macular hole had an open hole (stage 3) and underwent surgery during the period of this study. In all patients, the macular hole was closed as confirmed by optical coherence tomography after surgery. All the patients with cataract had a normal macula, and none of the patients with macular hole had any other ocular disease. Visual acuity was measured with full correction of the refractive error. All experiments were performed in accordance with the Declaration of Helsinki for research involving human subjects.

Multiple-Letter Acuity Chart

Several Landolt C's of the same size and with the gap pointing in the same direction are present on a single plate (45 × 45 cm). Although Snellen E’s could be used for this chart, the Landolt C’s are very familiar to all subjects in Japan. For a visual acuity of 1.0 and a testing distance of 5 m, the diameter of the Landolt C is equivalent to 5 minutes, and the gap in the ring is 1 minute. The spacing between the C’s is 33.3% of the diameter of the C’s. The spacing was varied in the first experiment but was constant in the other experiments. Plates for a visual acuity of 0.1 and 0.3 are shown in Figure 1. Fourteen plates that had C's for a visual acuity of 0.1, 0.15, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.2, 1.5, and 2.0, and the gap in the C's is randomly placed. This chart is presented at 5 m. When a subject cannot read the letter for a visual acuity of 0.1, the distance between the subject and the plate is reduced.

Effect of Interletter Spacing.

Visual acuity was measured with the standard visual acuity chart and the MLAC on normal subjects. The spacing between the letters was varied; three spacings of 20.0%, 26.7%, and 33.3% of the diameter of the C's were used.

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Visual Acuity Determined by the MLAC and the Standard Chart. Visual acuity was measured in patients with cataract, by using the standard visual acuity chart and the MLAC with a spacing of 33.3% of the diameter of the C's.

Pre- and Postoperative Visual Acuity in Patients with a Macular Hole. Visual acuity was measured before and after surgery in 16 patients after the closure of the macular hole, with the standard visual acuity chart and the MLAC. The spacing between the C's was 33.3% of the diameter of the C's.

RESULTS

Effect of Interletter Spacing

The visual acuities obtained from 15 normal subjects with the MLAC with the different spacings are shown in Figure 2. When the spacing was 20.0% of the diameter of the C's, the acuity measurement with the MLAC was lower than with the standard chart by more than two lines in 86.7% (13/15) of the subjects. When the spacing was 26.7%, the acuity measurement with the MLAC was lower by more than two lines than with the standard chart in 33.3% (5/15) of the subjects. When the spacing was 33.3%, none of the acuity measurements with the MLAC was lower by more than two lines than those obtained with the standard chart in all subjects. The acuity measurements obtained with the MLAC with any spacing were not higher than those obtained with the standard chart in all subjects. From these data, we selected a spacing of 33.3% of the C's for the following experiments.

Visual Acuity Determined by the MLAC and the Standard Chart in Patients with Cataract

The visual acuity measurements with the MLAC and the standard chart in patients with cataract are shown in Figure 3. A difference of more than two lines in the visual acuity measurement was not found in any of the subjects.

Pre- and Postoperative Visual Acuity in Patients with Macular Hole

The visual acuity measurements determined by the MLAC and the standard chart in patients before and after surgery are shown in Figure 4A. Before surgery, the acuity measurement determined by the MLAC was higher than that with the standard chart by more than two lines in 75% (12/16) of the patients (Fig. 4A). The lowest visual acuity measurement with the standard chart was 0.03, but the acuity measurement with the MLAC in this patient was 0.2 (Fig. 4A, #). After surgery, the acuity measurement determined by the MLAC was higher by more than two lines than obtained with the standard chart in 50% (8/16) of the patients (Fig. 4A).

A comparison of the pre- and postoperative acuity measurements with the two charts showed them to be very different (Fig. 4B). There was an improvement of visual acuities by more than two lines after surgery in 15 (94%) patients when the measurements were made with the standard chart, and 11 (69%) when the measurements were made with the MLAC.

Thus, both charts showed a significant improvement in mean visual acuity (log minimum angle of resolution [MAR]) after surgery (with the standard chart, before surgery, 0.94 ± 0.32, after surgery; 0.51 ± 0.26, P < 0.01; with the MLAC, before surgery, 0.58 ± 0.21, after surgery, 0.34 ± 0.13, P < 0.01). Although a significant improvement in visual acuity after surgery was shown by both charts, the improvement was significantly better for the acuities measured with the standard chart (Fig. 5).

DISCUSSION

In 1991, Kelly and Wendel1 reported that macular holes can be closed by vitrectomy and can bring about an improvement of
visual acuity. However, visual acuity measurements are often unreliable in patients with a macular hole. Many retinal surgeons have cases in which patients show large variations in the visual acuity measurement among examiners or on different testing days. In addition, some of the patients with a macular hole had visual acuity measurements of less than 0.1, although the diameter of most macular holes was less than 5°. According to Wertheim,15 the visual acuity is 0.2 at an eccentricity of 10°. These discrepancies can probably be attributed to anatomic changes in the foveal area. In patients with macular hole, the foveal cones are dislocated to the edge of the hole, and there are no cones in the center. The characteristic reports of metamorphopsia are dislocated to the edge of the hole, and there are no cones in the center. The characteristic reports of metamorphopsia16 by patients with macular hole has been explained by the dislocation of the cones.13 The loss of cone cells in the center of the fovea and the metamorphopsia cause a reduction in visual acuity, and the best visual acuity is obtained when the patient uses the point with the best minimum separable threshold eccentric to the hole. However, it is not always easy for patients to place the target on such points. The MLAC was designed to solve this problem.13

Theoretically, this chart presents the Cs to the macular region (5° × 5°), and patients can see the letters at points outside the hole without any effort or skill. The spacing between the letters should be small, to increase the probability that the letter will fall on the point with the best minimum resolution threshold. However, when the spacing between the letters is too small, the patients are confused and have difficulty in identifying the direction of the letter. This is probably caused by the crowding effect due to the destructive interaction of adjacent contours.17 The results (Fig. 2) showed that a 33.3% spacing was close to the minimum spacing that did not lead to such difficulties. With a spacing of 33.3%, the acuity measurement determined by the MLAC was almost identical with that obtained with the standard chart in patients with cataract (Fig. 3). These results suggest that media opacity does not alter the results for these two charts, as long as the fovea is normal.

The visual acuity measurements obtained with the two charts from patients with a macular hole were mixed (Figs. 4A, 4B). Thus, some of the patients achieved higher acuity measurements with the MLAC than with the standard chart—before surgery 75%, and after surgery 50%—but others did not show a difference of more than two lines. The preoperative visual acuity measurements with the standard chart were less than 0.1 in some patients (Figs. 4A, circles; 4B, triangles) which is not in accord with the data of visual acuity at eccentric points.15 In contrast, the visual acuity measurement with the MLAC, was higher than 0.15 in all patients (Figs. 4A, circles; 4B, circles) which is more compatible with the acuity at eccentric points. These results suggest that the MLAC successfully measured visual acuity at the extrafoveal point in patients with an open macular hole, but the standard chart failed to do so in some patients.

After surgery, both charts revealed a significant improvement in visual acuity. It is interesting that there was never a difference of more than two lines between the two charts in patients with a postoperative acuity measurements better than 0.5 (Fig. 4A, squares). On the other hand, in 8 of 12 patients with a postoperative acuity measurement lower than 0.5 with the standard chart, the MLAC revealed higher acuity measurements by two or more lines (Fig. 4A, squares).

After surgery, the retinal topography of the macular region was greatly improved, but Funata et al.,18 in a histopathologic study of a case involving a surgically closed macular hole, reported a small space in the fovea replaced by glial tissue. It is likely that patients with a postoperative acuity measurement better than 0.5 have a minimal or no dislocation of the cone cells and that they are able to see the target with the fovea, resulting in no difference in measurements with the two charts. However, the latter eight patients had some small but critical dislocation of the cells and continued to require eccentric fixation to see a letter on the standard chart, resulting in higher acuity measurements by two or more lines with the MLAC.

Our results (Fig. 5) demonstrated that the improvement in visual acuity after surgery was significantly less with the MLAC than with the standard chart. There are two possible reasons for the postoperative improvement of acuity with the standard
The eccentric visual acuity in patients with macular hole can also be measured by a grating acuity chart because the image of the grating falls outside the hole. In previous reports, grating charts gave higher acuity measurements than letter charts in patients with age-related macular degeneration and in the periphery of normal subjects. This is most likely because the grating is spectrally simple and does not require the complex task of reading letters. Therefore, if we use the grating chart in patients with macular hole, it is very difficult to know whether the difference of the results between the standard chart and grating chart is caused by a fixation problem or by a difference in the difficulty of the task. In addition, the letter acuity chart is familiar to patients and ophthalmology staff and is widely used for evaluating ocular diseases. Another reason is that the grating chart induces a strong metamorphopsia, such as the Watzke-Allen sign in some patients, and the letter chart does not induce such discomfort.

Finally, a question arises as to whether the MLAC measures practical visual ability. Our results suggest that MLAC provides a method of measuring the optimal visual acuity in patients with macular hole. However, if visual acuity measurements are intended to judge the usefulness of visual function or practical visual ability, the MLAC may not be better than the standard charts. To evaluate practical visual ability, other techniques are available. Of note, patients with an old bilateral macular hole (not included in this study) had the same acuity measurement (>0.2) on both charts, indicating that they had learned eccentric viewing. The MLAC may not estimate the practical acuity but the potential acuity. We are using both charts in all patients with a macular hole, and we can evaluate how patients learn to use eccentric fixation.

We conclude that the MLAC provides a quick and inexpensive evaluation of the potential capability of patients with macular hole. In addition, this chart may be useful for measuring visual acuity in patients with other macular diseases in which fixation is a problem, such as age-related macular degeneration and severe diabetic maculopathy.

References