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Abstract

A new instrument for visual field examination with binocular fixation is described. The binocular vision was dissociated with polarizing plates. Only the point of fixation was visible to both eyes while the testing chart (Amsler chart) was visible to one eye in the use of this apparatus. The examination was done with both the patient's eyes open. With the use of this apparatus, not only was the visual line fixed steadily in order to detect various changes of the central visual field due to maculopathy or optic neuropathy and these changes were detected accurately and quickly, but also suppression scotoma associated with amblyopia or squint could be detected quantitatively.

KEYWORDS: scotometer, binocular fixation, supression scotoma, amblyopia, scotoma

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A NEW APPARATUS FOR VISUAL FIELD TESTING WITH BINOCULAR FIXATION

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Abstra·t. A new instrument for visual field examination with binocular fixation is described. The binocular vision was dissociated with polarizing plates. Only the point of fixation was visible to both eyes while the testing chart (Amsler chart) was visible to one eye in the use of this apparatus. The examination was done with both the patient's eyes open. With the use of this apparatus, not only was the visual line fixed steadily in order to detect various changes of the central visual field due to maculopathy or optic neuropathy and these changes were detected accurately and quickly, but also suppression scotoma associated with amblyopia or squint could be detected quantitatively.

Key words: scotometer, binocular fixation, supression scotoma, amblyopia, scotoma

A number of scotometers facilitating detection of scotomata have been devised. Used frequently are the U-O test plates which can show the site of disease from the characteristics of a scotomata, Komoto's scotometer and Amsler charts which allow early detection of some maculopathies. However, none of these methods can be used with both eyes open, and in the presence of a central scotoma, when fixation of the visual line by one eye is unstable, with the result that positional and quantitative measurement of a scotoma is difficult. An apparatus for visual field examination with binocular fixation has been devised and manufactured. This apparatus dissociates binocular vision in a state close to natural seeing with both eyes open, stabilizes the visual line by binocular fixation, and reveals changes in the central visual field only in the eye to be examined while the subject does not know which eye is being tested.

This scotometer not only produces fixation and stabilization of the visual line in testing, but also allows detection of suppression scotomata due to interference by the other eye, which can not be detected by any routine monocular test.

MATERIALS AND METHODS

Apparatus. Amsler charts were used as the testing chart for central scotomata. The basic Amsler chart is a black surface 10 cm square partitioned every five mm by white lines vertically and horizontally, with a white fixation point at the center. The basic chart was printed on a milk-white dry-plate, making the white

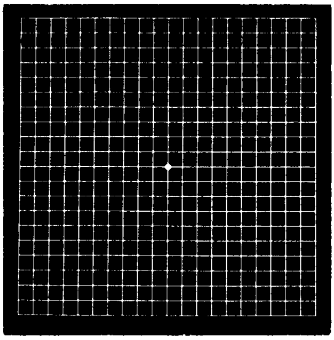

Fig. 1. Basic Amsler chart.

line and the central white point of fixation translucent to allow penetrating rays pass only through them (a in Fig. 2). When the center is observed from a distance of about 30 cm, the entire network corresponds to 20° of visual angle, and each small square to 1°. A polarizing filter was attached to the printed testing chart (b in Fig. 2) and a small hole was made on the polarizing filter at the site agreeing with the central point of fixation of the testing chart. The polarizing filter was fixed between a sheet of object glass and a cover glass and was halved horizontally in parallel with the testing chart at 28 cm from its surface and was placed in a gate-post-type support (c in Fig. 2). The polarizing direction of one of the halved ocular parts of the polarizing filter was the same as that of the polarizing filter at the testing surface, while that of the other is at 90 degrees. The light source was placed in the box below the testing chart in such a way that no light source spot was visible (d in Fig. 2). A separate box for power supply was attached to allow unrestricted switching and adjusting of light volume (Figs. 2, 3).

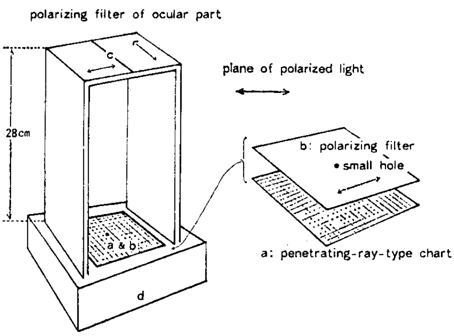

Fig. 2. Scotometer with binocular fixation.

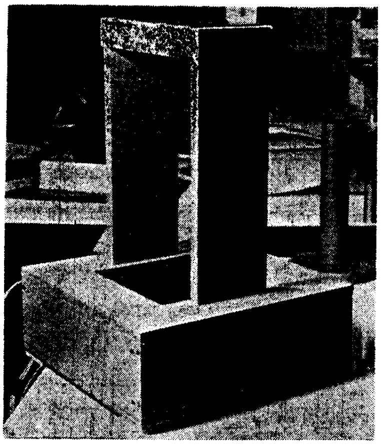

Fig. 3. Scotometer with binocular fixation.

Procedures for testing. The subject looks at the testing chart with both eyes from the front side of the ocular part through its polarizing filter. Since the polarizing filter of the ocular part is halved, the eye looking through the part in which the polarizing direction agrees with that of the polarizing filter on the surface of the testing chart can observe the central point of fixation and network, and the other can see only the central fixation point. That is, when both eyes are fixed on the central point of fixation, changes can be observed in the visual field within about 20° of the center (about 28° if a diagonal line is drawn) of only the eye to be examined. For testing the other eye, each polarizing filter in the ocular parts is rotated 90°, or the entire apparatus is rotated 180°. In order to detect changes of the central visual field with this scotometer, tests similar to those in the manual of Amsler charts were effective.

Practical measurements

Patients. A central scotoma was detected with the above apparatus in seven males and two females from five to 64 years of age who were examined at the Department of Ophthalmology, Okayama University Medical School and Okayama Rosai Hospital. The diseases examined included retinitis centralis in two cases, and one case each of macular degeneration, glaucomatous optic nerve atrophy, strabismic amblyopia (after operation for exotropia), eccentric fixation amblyopia, anisometropic amblyopia, microesotropia and organic amblyopia, a total of nine cases.

RESULTS

Case 1. 54-year-old male; diagnosis, right eye, macular degeneration; visual acuity, right=0.01 (0.03× +cyl. 1.0 DA 180°), left=1.5 (n. c.).

Bleeding from the macular region was detected two years before. On ophthalmoscopic testing, degeneration of the macular region was observed, and a central scotoma of about 2.5° was observed as a result of a test with the apparatus (Fig. 4). Because of the central scotoma, testing with one eye was difficult.

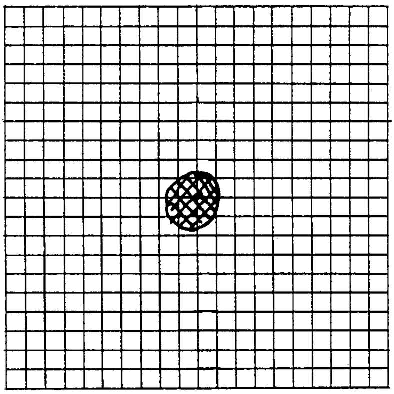

Fig. 4. Central scotoma in right maculopathy.

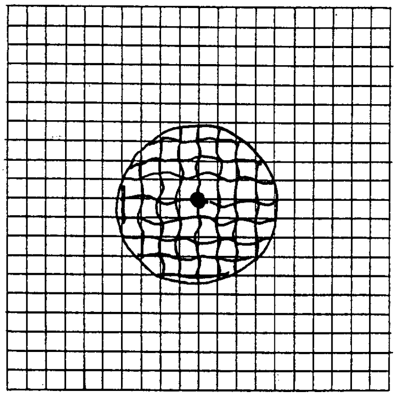

Fig. 5. Central scotoma in retinitis centralis of left eye.

Case 2. 39-year-old male; diagnosis, left eye, retinitis centralis; visual acuity, right=1.5 (n. c.), left =0.6 (0.7× +0.5 D).

There was edema in the macular region of the left eye, in agreement with which, a central scotoma about 8° in diameter was noted in the central visual field of the left eye (Fig. 5).

Case 3. 34-year-old male; diagnosis, right eye, retinitis centralis; visual acuity, right=0.4 (0.8 × +1.5 D), left=1.5 (n. c.).

The patient came to the hospital complaining of blurred vision lasting for three weeks. There was slight detachment in the retina of the macular region of the right eye, agreeing with which a scotoma including the center was observed in the nasal lower potion (Fig. 6).

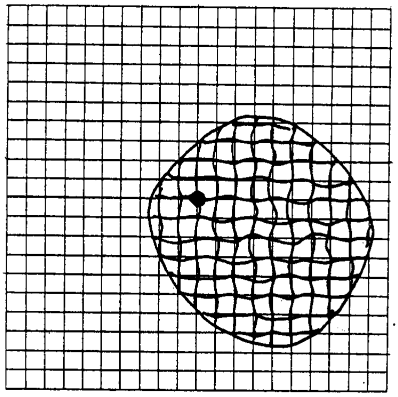

Fig. 6. Central scotoma in retinitis centralis of right eye.

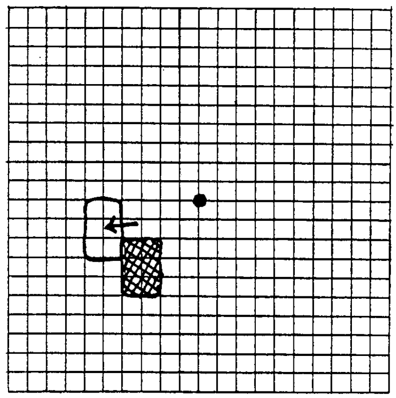

Fig. 7. Paracentral suppression scotoma after operation for strabismus.

Case 4. 32-year-old male; diagnosis, postoperation of exotropia; visual acuity, right=0.4 (1.2 × −0.5 D ⊃ -cyl. 0.75 D A 90°), left=0.3 (1.0 × −1.0 D ⊃ -cyl. 0.75 D A 90°).

Orthophoria was observed after an operation for exotropia. Visual acuity under the binocular condition showed no change from the monocular visual acuity, and the test for binocularity showed only a little fluctuation in the S. F. P. slide. The fusional amplitude was normal, and stereopsis was possible. The apparatus for visual field testing with binocular fixation demonstrated a small paracentral visual field of the left eye. This scotoma fluctuated slightly and was not detected by the monocular test. It is thought, therefore, to be a suppression scotoma (Fig. 7).

Case 5. 9-year-old female; diagnosis, right eye, eccentric fixation amblyopia, visual acuity, right=2.0 (n. c.), left=0.2 (n. c.).

Visual acuity under the binocular condition, left =0.1 (n. c.). Fixation, left eye, nystagmoid parafoveal; binocularity (synoptophore) S. P. P. (±), S. M. P. (±), S. F. P. (±).

A suppression scotoma (Fig. 8) was observed when tested with this apparatus on January 23, 1972. As a result of antisuppression training, the suppression scotoma changed slightly (Fig. 9) on February 12, 1972, but not to the extent of

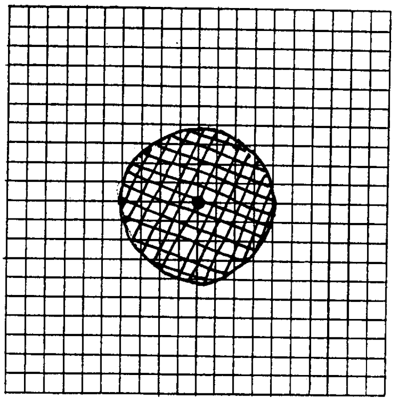

Fig. 8. Suppression scotoma in eccentric fixation amblyopia of left eye.

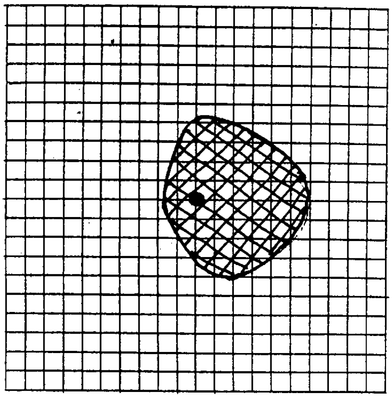

Fig. 9. In spite of the antisuppression training, the suppression scotoma changed only a little.

disappearance. This scotoma was not detected by a monocular test on either day.

Case 6. 5-year-old male; diagnosis, left eye, amblyopia, both eyes, hypermetropia.

June 23, 1971; visual acuity, right=1.0 (1.0× +0.5 D), left=0.6 (0.7p × +1.25 D).

Suppression was observed on S. F. P. slide in the left eye with a synoptophore, and at the same time, with the binocular fixation test a scotoma was observed in the left eye (Fig. 10). This scotoma was not detected under monocular conditions.

February 16, 1972; visual acuity, right =1.2 (1.2× +0.5 D), left=0.7 (1.0× +1.25 D ⊃ +cyl. 0.75 D A 90°).

The visual acuity of the left eye was improved by antisuppression training, the corrected visual acuity beeing 1.0. At the same time, the synoptophore showed complete binocularity. No suppression scotoma was detected with this apparatus, demonstrating the effect of training.

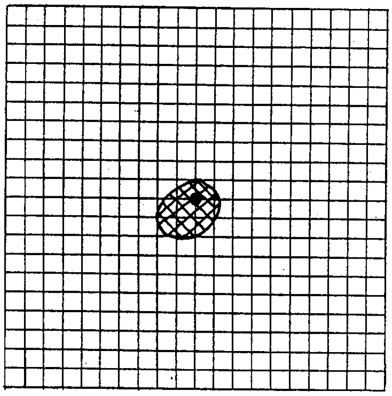

Fig. 10. Suppression scotoma in amblyopia of left eye.

Case 7. 5-year-old female; diagnosis, esotropia, harmonious abnormal retinal correspondence, and hypermetropic astigmatism of both eyes.

Visual acuity, right=(1.2× +1.0 D ⊃ +cyl. 1.0 D A 90°), left=(0.9× +6.5 D ⊃ +cyl. 0.75 D A 90°). Visual acuity under the binocular condition, left= (under 0.1).

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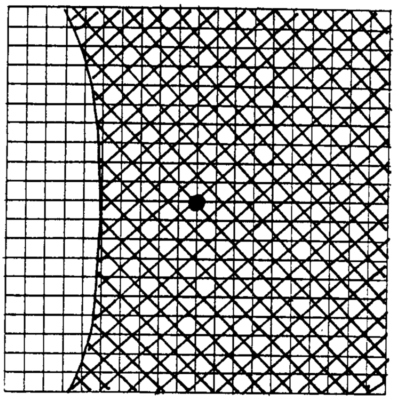

Fig. 11. Hemianoptic suppression scotoma in the case of microesotropia.

Hess chart, harmonious abnormal retinal correspondence Fly test only possible in part of circle.

A nasal hemianoptic suppression scotoma including the center was observed in the left eye with this apparatus (Fig. 11). This scotoma was not detected by a monocular test.

Case 8. 18-year-old male; diagnosis, left eye, amblyopia; visual acuity, right =1.5 (n. c.), left=0.9 (n. c.).

Visual acuity under binocular condition, left=0.3 (n. c.).

Under the above diagnosis the patient has been given amblyopic treatment for quite a long time after the initial examination in 1967. The test with this apparatus revealed a scotoma as shown in Fig. 12. This scotoma did not disappear even when the right eye was covered, suggesting the presence of an organic disease (it was not a suppression scotoma). However, ophthalmoscopy revealed no abnormal findings in the fundus, nor did retinal fluorescein angiogram reveal anything abnormal. Hardly any change was observed in the size of the scotoma following an injection of Isomytal.

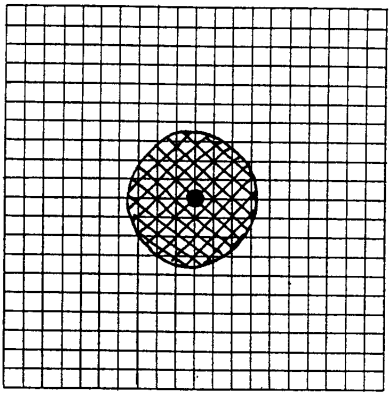

Fig. 12. Central scotoma in organic amblyopia of left eye.

Case 9. 64-year-old male; diagnosis, right eye, chronic glaucoma and glaucomatous optic nerve atrophy, left eye, absolute glaucoma.

Visual acuity, right=0.8 (1.0× −1.0 D), left=0 (n. c.). Intraocular pressure, right, 34.4–34.5 mmHg, left, 64.0 mmHg (by Schioetz).

The optic disc of the right eye showed a marked glaucomatous cup with atrophy. There was an advanced visual field loss, kinetic perimetry with Goldmann's perimeter with only a central visual field of 5° in the tempolar side, 15° in the nasal side, 4° upward, and about 8° downward and an insular field in the lower portion (Fig. 13). A test with this apparatus reveals only a small defect at the angle of the temporoinferior portion of the left eye on the chart (Fig. 14).

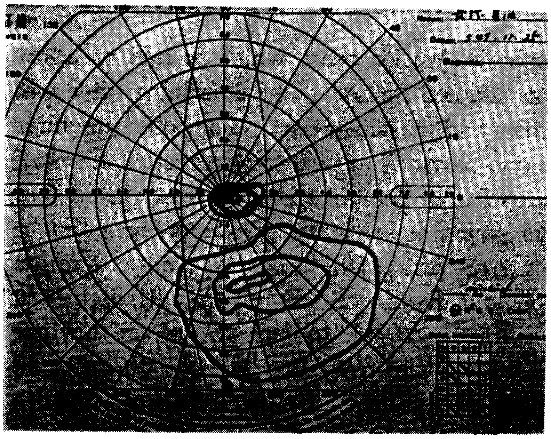

Fig 13. Visual fiield (kinetic perimetry) in glaucoma of right eye.

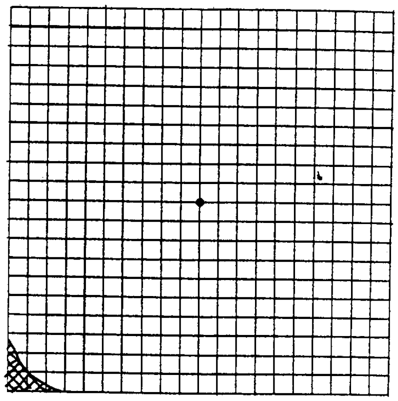

Fig. 14. Central field of right eye of the case in Fig. 13 with this apparatus.

DISCUSSION

Visual field testing has been performed since ancient times, and according to Morton (1), perimetry was referred to in chapter 12 of Galan's treatise at the end of the second century. The original field testing included only measurement of the peripheral limits of the visual field and direction of the region of defect in the visual field, that is, the scotoma. More recently, visual function of the retina of various regions in the visual field is expressed quantitatively by visual acuity or differential thresholds using variouse methods. However, peripheral perimetry and the central scotometry have not lost their clinical value although they are classic. Depending on the disease, the classic perimetry or scotometry is essential for diagnosis or observation of the course. In particular, many scotometers have been devised in order to detect and record easily changes in the center of the visual field with the highest visual function. Examples are the U-O test plate (2) said to allow estimation of the site of disease from the characteristics of scotoma; Komoto's scotometer (3) used widely in Japan; Amsler charts (4) said to allow early detection of maculopathy; Pritikin's portable hand tangent screen (5); and the portable campimeters of Nakashizu (6), Kitahara (7) and Sugimura (8). As a method for stabilizing the visual line to detect and record central scotomata more accurately, procedures for making the normal eye (the other eye) fix have been reported. Examples are Onishi's binocular campimeter (9-11) by application of a stereoscope, Hobb's stereocampimetry (12), and the scotometries of Hallden (13) and Okuda (14) by using polarized light. Schlosser, Yamazi (15) and Baisinger (16) reported a method in which the subject watches the fixation point through colored glass to detect a scotoma with a target of complementary colors.

In the present apparatus, the basic Amsler chart which is said to allow early detection of maculopathy was adapted for use. The polarizing filter was fixed to the surface of the testing chart and the ocular part. The polarizing filter of the ocular part was divided into two parts. The polarizing direction of one of the ocular parts was made the same as that of the polarizing filter of the surface of the testing chart while the other part was at right angles. As the point of fixation, a small hole was made in agreement with the central point of fixation on the testing chart, so that the point of fixation might be seen with both eyes. With this apparatus, the point of fixation is visible to both eyes when they are open, producing satisfactory stabilization of the visual line, but the testing chart is visible to only one eye (the eye to be examined). Subjects can not tell with which eye they are looking at the testing chart, so that binocularity is dissociated very naturally. In the preexisting methods of binocular fixation for stabilization of the visual line, Schlosser's (15, 16) uses the spot visible only to the fixing eye. In the method of Okuda (14) using polarized light, the point of fixation is looked at only by the fixing eye which is completely dissociated from the eye to be examined. The point of fixation of this new apparatus is visible to both eyes. It is not only better than the methods heretofore which dissociate binocularity completely, ensuring more stability of the visual line, but also more advantageous, showing interference of the fixing eye with the eye to be examined in a more natural state. In other words, suppression scotoma can also be detected (Cases 4-7). These suppression scotomata are not produced by sending to the fixing eye an image different from that of the retina of the eye to be examined. The polarizing filter of the ocular part was fixed on a gate-post-type mount to ensure complete maintenance of the relationship in which the polarized light is in the same plane as the polarizing filter of the surface of the testing chart, or at right angles to it, avoiding the disadvantage of the method of Okuda (14) in which the subject wears polarizing glasses, dissociation of binocularity is difficult unless the head is fixed firmly. In this new apparatus, whichever direction the head is in, binocularity is dissociated for testing, as long as the visual line of each eye passes through the polarizing filter of each ocular part.

The range measurable by this scotometer is about 20° of visual angle around the fovea in the retina. The changes of the visual field in the peripheral retina can not be detected (Case 9). However, with regard to showing visual changes in the center, the present apparatus retains the characteristics of Amsler charts with no changes. That is, it allows early detection of maculopathy, and if a complete test is made with a uniform questionnaire system, it can elucidate changes in the visual field regionally and quantitatively.

By making testing charts of a penetrating-ray-type, it became possible to detect changes in the visual field for color by piling color filters. Although in testing with both eyes open the ocular position can pose a problem, it is possible to concentrate the visual line of both eyes upon the fixation point by mounting rotary prisms on the ocular parts without requiring a strong fusional vergence. In research, it can be used to demonstrate the conditions of the central visual field which occur by changing the visual line of both eyes. Because it is possible to pile a correction lens upon the ocular part, abnormalities of the accomodation can be corrected so that apparent changes of the central visual field accompanying anomaly of refraction can be eliminated.

Since the sensitivity of this scotometer is high, various figures of fusion were tried as the fixation object. However, even in eyes with normal visual field and binocularity, a zone of suppression appeared around the fixation figure, necessitating the use of a point index. Maintenance of the visual lines with both eyes did not require a rotary prism except for strabismic or amblyopic patients.

When a testing chart of a penetrating-ray-type is printed and the polyester sensitive film reported by Kamiya (17) is used, a testing chart with high precision can be manufactured.

There are many reports on suppression scotoma (18–21), and results of observation of suppression scotoma using the present apparatus will be reported in a separate paper.

Acknowledgment. I wish to thank Prof. Nobuhiko Matsuo for reviewing the manuscript.

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Errata. In the issue of *Acta Medica Okayama* Vol. 32 No. 2, the date of receipt of the manuscript by Masahiro Miyazaki *et al.* on page 85 was inadvertently omitted. The manuscript was received on December 19, 1977. In the same issue, ANE in the title of the Brief Note by Hajime Ogura *et al.* on page 169 should be AND.