AUTOMATED FLICKER PERIMETRY IN GLAUCOMA AND RETINAL DETACHMENT PATIENTS

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Abstract

The authors studied the relationship between the critical fusion frequency (CFF) and the threshold value of differential light sensitivity in glaucoma and retinal detachment patients. One hundred and fifty eyes of 82 glaucoma patients and 27 eyes of 27 retinal detachment patients were examined by both light-sense perimetry, using the Octopus 201, and flicker perimetry, using the Octopus 1-2-3. In glaucoma patients, the authors studied the correlation between light sensitivity and flicker sensitivity in the area where nerve fiber layer defects (NFLD) were observed. In retinal detachment patients, they studied the area where the retina had been detached. In glaucoma patients, when the threshold values of differential light sensitivity decreased from 30 to 20dB, the CFF decreased from 40 to 5 Hz. Many test points where the values of differential light sensitivity were less than 15dB were shown to be 0 Hz by flicker perimetry. On the other hand, in retinal detachment patients, light-sense perimetry detected more abnormal points than flicker perimetry. In abnormal points where the threshold values of differential light sensitivity were less than 15dB, the CFF never decreased to 0 Hz by flicker perimetry. The results showed that flicker perimetry was more sensitive and useful for the detection of visual field defects of glaucoma than for those of retinal detachment.

Introduction

It is known that flicker perimetry is more sensitive than traditional light-sense perimetry for detecting third neuron disorders such as glaucomatous visual field defects1-10. Recently, evidence from several laboratories has suggested that the large ganglion cells which project to the magnocellular layers of the lateral geniculate body selectively die in glaucoma11. The critical fusion frequency (CFF) is one of the temporal transfer properties and is the suitable stimulus for detecting early glaucomatous visual field defects. On the other hand, it has also been reported that flicker perimetry is less sensitive than light-sense perimetry for detecting photoreceptor level disorders1,2,12. However, there have been only a few clinical comparative studies of third neuron disorders.
disorders and photoreceptor level disorders using flicker stimulus. We studied the relationship between the CFF and the threshold value of differential light sensitivity in glaucoma and retinal detachment patients using our automated flicker perimeter.

**Subjects and methods**

**Glaucoma patients**

Measurement was carried out in a total of 150 eyes of 82 subjects: 121 eyes of 67 patients with primary open-angle glaucoma, 25 eyes of 13 patients with normal-tension glaucoma, and four eyes of two patients with secondary glaucoma. The stages of their visual field defects were as follows: 64 eyes had stage 0-1, 56 eyes stage 1, and 30 eyes stage 2, according to Aulhorn's classification modified by Greve et al.\textsuperscript{13}. The mean age of the study population was 52.7 ± 11.1 years (minimum, 27 years; maximum, 75 years). The inclusion criteria were as follows: pupil diameter of ≥ 3.0 mm; corrected visual acuity of ≥ 20/20; refractive errors of ≤ 6.5 D (spherical) and ≤ 3 D (cylindrical) and clear optical media.

**Retinal detachment patients**

Measurement was carried out in a total of 27 eyes of 27 subjects. Their postoperative follow-up periods were as follows: four eyes within one month, five eyes from one to five months, five eyes from six to 11 months, and 13 eyes more than one year. The mean age of the study population was 39.2 ± 17.4 years (minimum, 22 years; maximum, 67 years). The postoperative corrected visual acuity was as follows: 16 eyes were 20/20 or better, nine eyes from 20/25 to 20/40, and two eyes from 20/50 to 20/200. The postoperative refractive errors were as follows: nine eyes were less than −4.0D, 12 eyes from −4.5D to −6.0D, four eyes from −6.5D to −8.0D, two eyes more than −8.5D (spherical), and 27 eyes less than 3.0D (cylindrical). Their pupil diameters were more than 3.0 mm. No marked postoperative secondary cataracts were observed in any of these patients.

**Visual field test**

Light-sense perimetry was performed using the Octopus 201 (Interzeag) program No. 32, with a stimulus size 3 under the background luminance of four asb. The duration of each target stimulus was 100 msec. The Peridata (Interzeag) was used for each individual field analysis.

Flicker perimetry was performed using the Octopus 1-2-3 and a personal computer with our original program\textsuperscript{10}. The arrangement of test points was the same as Octopus Program No. 38. Flicker perimetry was performed with a stimulus size 3 under the background luminance of 31.5 asb. The duration of each target stimulus was one second. Age-related normal values from 100 normal eyes of 100 individuals were used for flicker field analysis. Light-sense perimetry and flicker perimetry were performed within a period of two months in glaucoma patients, and within a period of two days in retinal detachment patients.
Automated flicker perimetry

In glaucoma patients, red free fundus photographs and images of the Scanning Laser Ophthalmoscope (SLO) (Rodenstock) were used for the detection of nerve fiber layer defects (NFLD). Red free fundus photographs were taken with a CF-60U (Canon) 60° fundus camera, using Kodak 2414 Technical Pan film and a Kodak Wratten filter No. 44A. An SLO was also used for the detection of NFLD with an argon blue laser beam and a C1 aperture. Using composed images of red free fundus photographs and visual fields, we compared the difference between the CFF and the value of the differential light sensitivity in the area where the NFLD was observed.

In retinal detachment patients, fundus photographs were taken with a CF-60U (Canon) 60° fundus camera before and after surgery. Using composed images of fundus photographs and visual fields, we compared the difference between the CFF and the value of differential light sensitivity in the area where the retina had been detached (Fig. 1). We studied 13 eyes of retinal detachment patients, whose postoperative follow-up periods were more than one year.

**Results**

**Glaucoma patient**

Case 1 was a 56-year-old male with primary open-angle glaucoma. Corrected vision of both eyes was 20/20. The intraocular pressure in his right eye was 19 mmHg, in his left eye
The cup/disc ratio of his right eye was 0.5, of his left eye 0.8. The red free fundus photograph of his left eye showed the NFLD in the upper and lower temporal retina. Light-sense perimetry showed abnormal test points in the lower nasal visual field (Fig. 2a). Flicker perimetry showed the area of further advanced CFF loss in his lower nasal visual field (Fig. 2b).

Retinal detachment patient

Case 2 was a 19-year-old female with a retinal detachment in her left eye. Her left eye showed shallow retinal detachment in the temporal retina. Corrected vision was 20/20 in both eyes. The intraocular pressure in her right eye was 15 mmHg, in her left eye 14 mmHg. Before retinal detachment surgery, Octopus perimetry showed a sensitivity loss in her nasal visual field (Fig. 3a). Flicker perimetry also showed a CFF loss in her nasal visual field (Fig. 3b). Three weeks after surgery, Octopus perimetry showed the area of still diffuse sensitivity loss in her nasal visual field (Fig. 4a). However, flicker perimetry showed almost normal CFF values in her left visual field (Fig. 4b).

Figure 5 shows the relationship between CFF and differential light sensitivity in glaucoma.

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**Fig. 2a.** Case 1. Grayscale and comparison of light-sense perimetry.

**Fig. 2b.** Case 1. Value table and probability of flicker perimetry.
and retinal detachment patients. The horizontal axis shows differential light sensitivity and the vertical axis shows CFF. The sizes of the rings are proportional to the numbers of the test points, which are plotted at the same point. The closed circles show test points of glaucoma patients where the NFLD were observed. The open circles show test points of retinal detachment patients where the retina had been detached.

In glaucoma patients, when differential light sensitivity decreased from 30 to 20dB, CFF decreased remarkably from about 40 to 5 Hz. Many test points where differential light sensitivity was less than 15dB were shown to be 0 Hz by flicker perimetry in glaucoma patients.

On the other hand, in retinal detachment patients, when differential light sensitivity decreased from 30 to 20dB, CFF decreased gradually. In abnormal points where the threshold values of differential light sensitivity were less than 15dB, CFF never decreased to 0 Hz in flicker perimetry.
Discussion

Our data show that flicker perimetry using the Octopus 1-2-3 is more sensitive for the detection of glaucomatous visual field defects than for those of retinal detachment. In 1959, Nakabayashi developed a method of kinetic flicker perimetry using a modified Goldmann perimeter, and studied several kinds of ocular diseases. He reported that flicker perimetry was less sensitive for retinal diseases such as central serous retinopathy than for glaucoma and neuro-ophthalmological diseases. In 1973, Otori et al. developed a central CFF meter for evaluating foveal CFF value. They reported that the CFF value decreased more remarkably in third neuron disorders such as optic neuritis than in other ocular disorders such as retinal diseases. These studies suggest that CFF is a suitable stimulus for evaluating the function of the third neuron. It is known that there are parvocellular cells and magnocellular cells of the retinal ganglion cells. Flicker stimulus, which has a high contrast and high temporal resolution, is a suitable stimulus for evaluating the magnocellular function.

In retinal detachment patients, both light-sense perimetry and flicker perimetry showed sensitivity loss in the area where the retina was detached. The function of the photoreceptor is severely disturbed in the detached retina, so it is reasonable to assume that both the value of differential light sensitivity and of CFF decrease in this area. When flicker perimetry...
Automated flicker perimetry

was performed, our patients sometimes could not recognize the flicker target nor the not-flickering target on the detached retina.

However, the CFF value recovered to the normal range within a few weeks after the retina was reattached. On the contrary, the value of differential light sensitivity recovered slowly within a year or so. In 1984, Folk et al. reported that, in central serous retinopathy, the CFF values recovered to the normal range soon after resolution of the subretinal fluid. However, the value of differential light sensitivity by Octopus perimetry improved slowly and was still abnormal even after long-term follow-up. Once the retina is detached, the photoreceptor and the retinal pigment epithelium are damaged, and this damage continues even after the retina is reattached. Our results suggest that the CFF value is not affected by this slight damage to the photoreceptor.

In addition, refractive errors increase due to scleral buckling and encircling after retinal detachment surgery. Secondary cataracts also increase after retinal detachment surgery. It is also known that flicker perimetry is less influenced by refractive defocusing and artificial media opacities, which cause retinal image degradation.

The above finding that the CFF values decrease more selectively in third neuron disorders than in photoreceptor level disorders seems to be a definite advantage in evaluating glaucomatous visual field defects in clinical practice.

References


Fig. 5. Relationship between CFF and differential light sensitivity in glaucoma and in retinal detachment patients. Sizes of the rings are proportional to the number of test points plotted at the same point.