EVALUATION OF FIXATION DURING PERIMETRY USING A NEW FUNDUS PERIMETER

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Introduction

The accuracy of perimetry depends on the stability of the subject's gaze. Unstable fixation spoils the accuracy. It is very difficult for even cooperative subjects to keep a stable gaze during an examination because it is impossible to completely fixate the eyes. When the gaze is unstable, small scotomata cannot easily be detected, especially with fundus perimetry[1-4]. There are few studies on the subject of fixation during perimetry. In order to evaluate the fixation accuracy, we measured eye movements and gaze deviations from a fixation point during perimetry, employing a new fundus perimeter that pursues eye movement[4].

Methods

Subjects

Five normal subjects and two patients with glaucoma were examined. The visual acuity of each subject was more than 1.0. All subjects had extensive experience with standard perimetry.

Equipment

For this study, a new fundus perimeter was employed, consisting of three components: an infrared fundus camera, a target device and a pursuit device (Fig. 1). A fundus image is sent from the fundus camera to the target device. The image is recognized by a video board in the pursuit device (Fig. 2). The pursuit device can detect and pursue the drift of the image, when gaze deviation occurs. The degree of gaze deviation can be evaluated by the drift of the fundus image. The minimal angle of the gaze

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deviation that can be detected by the pursuit device is 0.05°. The deviation data are memorized as X-Y coordinates in the computer memory of the pursuit device. The sampling rate is 20 times per second. The target device can show the fixation target and the test stimulus on a liquid crystal monitor installed in the fundus camera. The brightness of the target can be varied from 2 to 107 asb in the target device.

Measurement

Perimetry was performed using fixation targets consisting of a dot and a circle. The size of each was 0.1 and 10° in diameter. The fixation target's brightness was 107 asb. The brightness of the background was 2 asb. The subjects were asked to gaze at the fixation target on a monitor during perimetry. When the stimulus points were randomly generated on the same monitor, the subjects must respond by clicking a mouse. The size and brightness of the stimulating points were 0.05° and 107 asb, respectively. The deviation of the subject's gaze from the fixation target could be calculated as the drift of the fundus image by the pursuit device. The sampling rate was 20 times per second. The duration of each examination was three minutes.

Results

Figure 3 shows the average magnitude of eye movement which occurs between samplings during the examination. Figure 3a shows the average magnitude in normal and glaucoma subjects when gazing at the dot fixation target. There is no great difference

Fig. 1. Our new fundus perimeter.

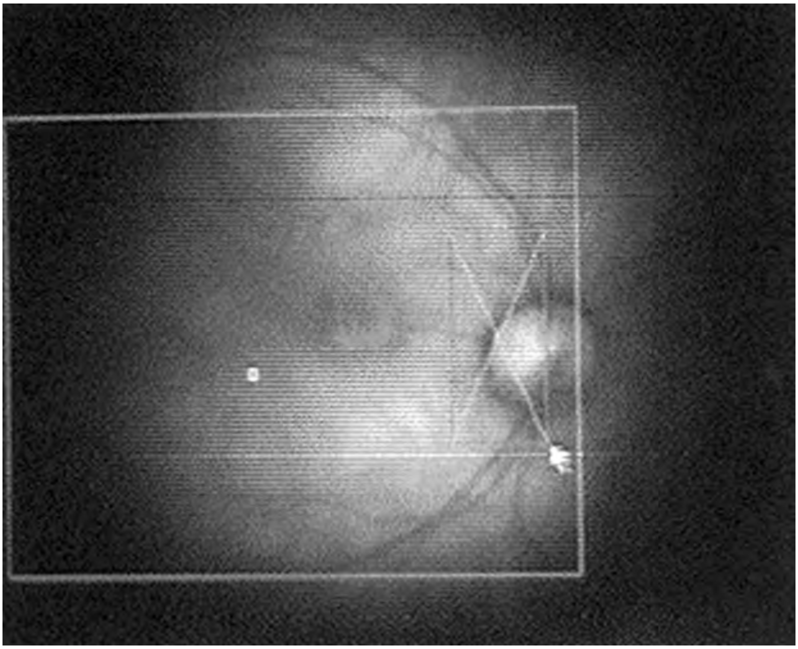

Fig. 2. The pursuit device.

between these groups. The average is very small, less than 0.1°. The magnitude gradually increased as the examination progressed. Figure 3b shows the difference between the magnitude of eye movement for the fixation targets of both the dot and circle. The average eye movement using the circle target is much larger when the dot target is used.

Figure 4 shows the distribution of eye movement components. The horizontal components dominate the vertical ones. The average degree of gaze deviation using the dot and circle fixation targets is shown on Figure 5. Fixation stability with the circle targets is much worse than with the dots. Ninety-seven percent of the deviations were within 1° with the dot targets. Large deviations of more than 3° frequently occurred at the rate of 10%.

In order to evaluate the influence of the gaze from the stimulus points, we analyzed the gaze deviation from the fixation target immediately after turning on the stimulus point. Because the stimulus points were lighted at random sites, the direction of the stimulus sites from the fixation target varied. Thus, the coordinate axes revolved around the fixation point as the direction changed. The coordinate values of the deviation can be transformed, adapting to the coordinate axis as it revolves. The arrow in Figure 6a shows the direction of the stimulus site from the fixation point. The circles show the size and direction of the gaze deviation from 0.1 to 1.5 seconds after turning on the stimulus points. There was a tendency for the direction of the gaze deviation to correspond relatively to the stimulus site. This means that the subject's gaze was lured to the stimulating point after it was presented. Figure 6b shows that the deviation becomes larger after 0.3 to 0.7 seconds, recovering after 1.3 seconds.

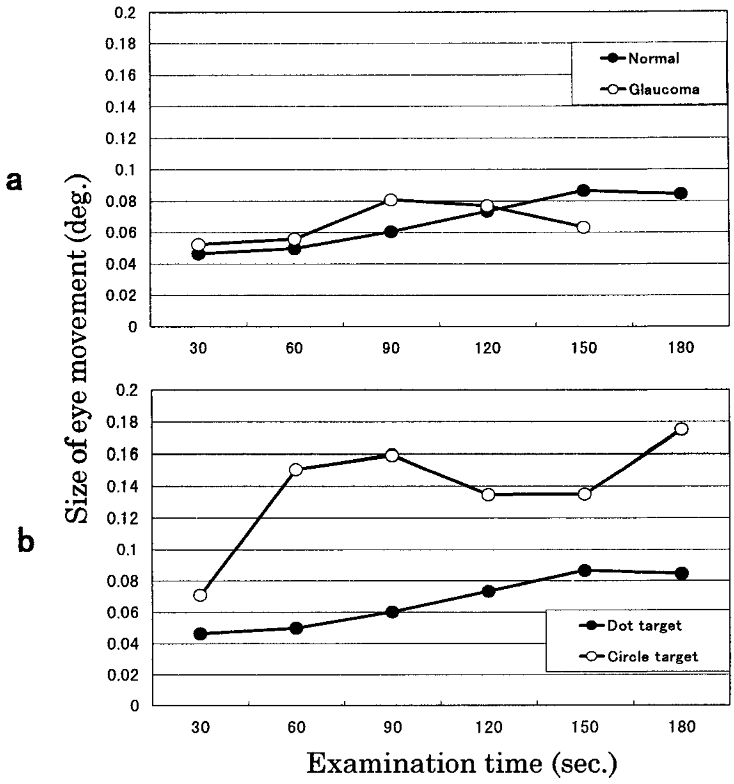

Fig. 3. The average size of eye movement occurring between samplings during the examination.

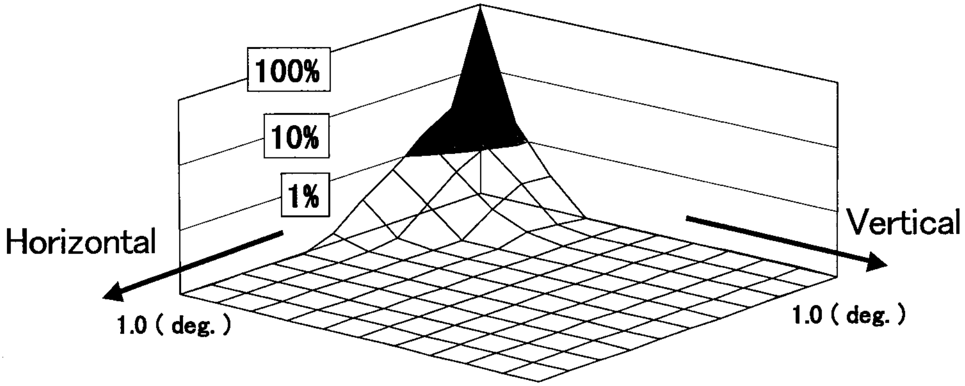

Fig. 4. The distribution of eye movement components.

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Fig. 6. Influence of the gaze from the stimulus points. The circles show the size and direction of the gaze deviation from 0.1 to 1.5 seconds (indicated in the open circle) after turning on the stimulus targets. The arrow shows the direction of the stimulus site from the fixation point.

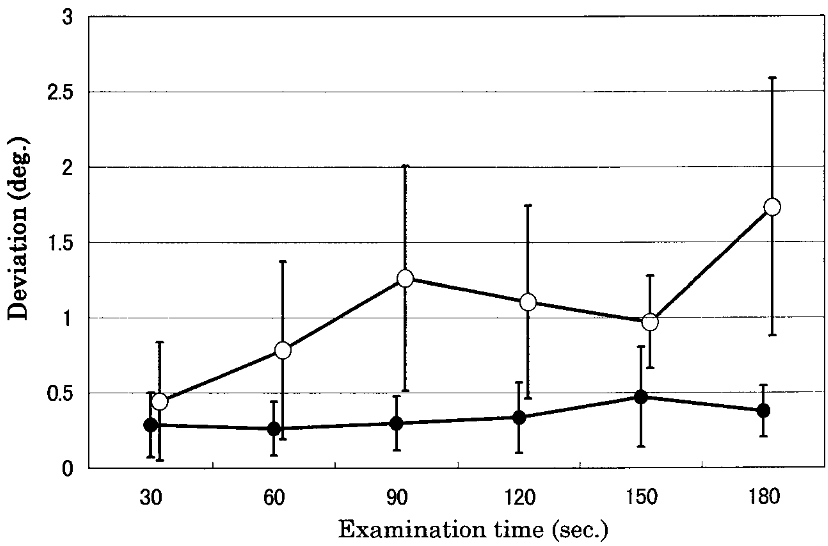
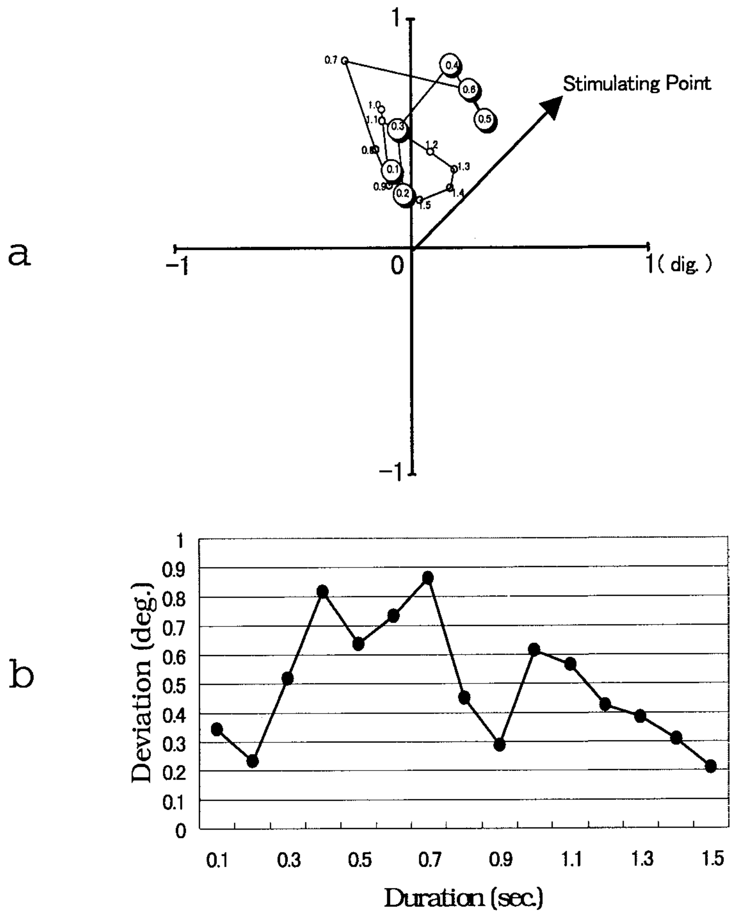


Fig. 5. The average size of gaze deviation using the dot and circle fixation targets. *Closed circle:* dot target; *open circle:* circle target.



Discussion

In this study, we examined subjects who had good visual acuity. The stability of their gaze to the dot fixation target was much better than expected. It is thought that the accuracy of perimetry is better in subjects with good visual acuity. Very small eye movements dominated during the examination. It is thought that these movements were caused by the physiological nystagmus during fixation, the average size of the deviation from the dot target ranged within 1.0°. We also used a circle fixation target in order to examine the state in which the subjects gazed without foveation. The fixation stability became worse, and large deviations of more than 3.0° frequently occurred. These large deviations make the detection of small scotomas very difficult, especially in fundus perimetry. Therefore, it is necessary to decrease the influence of gaze deviation when subjects with poor visual acuity are examined using this new technology. In order to resolve this problem, we have developed a new fundus perimeter that automatically pursues eye movement.

In this study, we confirmed that the stimulating targets have an influence on fixation stability. The subject's gaze was lured by the stimulating targets. This influence continued for about 1.0 seconds immediately after presenting the target. These results show that adequate intervals between the stimulating sequences should be established.

Conclusions

Subjects with good visual acuity could fixate very well during perimetry. Almost all deviations were very small and probably caused by physiological nystagmus during fixation. It is necessary to develop a new method that decreases large gaze deviation of subjects with poor visual acuity. Stimulating sequence intervals should be established in order to avoid the influence of stimulus or fixation.

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