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Relationship Between Visual Field Defect and Multifocal Electroretinogram

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Abstract: We investigated the effect of artificial parafoveal scotomata on the multifocal electroretinogram (M-ERG). M-ERGs were recorded from normal subjects using a monitor with several different sizes of black paper attached. A lower response density area around the 10 to 15 degree parafoveal region was not recognized for scotomata up to 3 degrees but was observed in scotomata above 5 degrees (visual angle) in the field topography of M-ERG. The shape of the scotomata was not circular but somewhat oval. The results from two cases of parafoveal retinal degeneration accorded well with this basic study. **Jpn J Ophthalmol 1998;42:136–141** © 1998 Japanese Ophthalmological Society

Key Words: Degeneration, electroretinogram, multifocal, parafovea, retina, scotoma.

Introduction

The multi-input stimulation technique[1] enables us to obtain many focal electroretinograms (ERGs) simultaneously. Additionally, these focal ERGs can be reconstructed into a topographical image as an objectively examined "functional" visual field. However, basic research on multifocal ERG (M-ERG)[1,2] has never been completed before. It is necessary to analyze further data recorded from normal subjects to determine the clinical application of M-ERG. Although this stimulus system is useful in understanding foveal as well as parafoveal retinal function, there have been few papers written concerning the relationship between M-ERG and visual field defect. To evaluate their ability to detect visual field defect, M-ERGs were recorded for normal subjects using various sizes of artificial scotomata, and from two patients with retinal degeneration with parafoveal scotoma.

Methods

The M-ERGs were recorded using the VERIS III system (Tomey Co., Ltd, Nagoya, Japan). The stimuli consisted of densely arranged arrays of 103 hexagonal elements. They were displayed on a CRT monitor (Sony Co., Ltd., Tokyo, Japan) (42 deg. high by 45 deg. wide) to three normal subjects (27, 40, and 58 years of age, respectively) as well as two patients with parafoveal retinal degeneration. Each hexagonal element was independently altered between brightness and darkness according to a pseudorandom sequence mode (binary m-sequence) at a frequency of 75 Hz. The mean luminance was 91 cd/m^2 (Lmax = 178 cd/m^2, Lmin = 4 cd/m^2) and the contrast was 95%. The pupils were fully dilated using drops of 0.5% tropicamide and 0.5% phenylephrine/HCl solution. M-ERGs were recorded using a bipolar contact lens electrode after corneal anesthesia with two drops of oxybuprocaine chlorhydrate solution. One or more drops of artificial tears (sodium hyaluronate) were added before lens insertion. A ground electrode was placed on the ipsilateral ear lobe. All of the subjects were seated comfortably with their chins and foreheads tightly fixed, looking monocularly at the fixation point (F in Figure 1A) in the center of the CRT monitor. The distance between the tested eye and the CRT monitor was 32 cm. Signals were amplified using model 12-4 Neurodata Acquisition System (Astro-Med, Inc. Grass Instrument Division, West Warwick, RI, USA) and band-pass filtered from 10 to 300 Hz. It took 4 minutes to obtain one M-ERG record, and eight sessions

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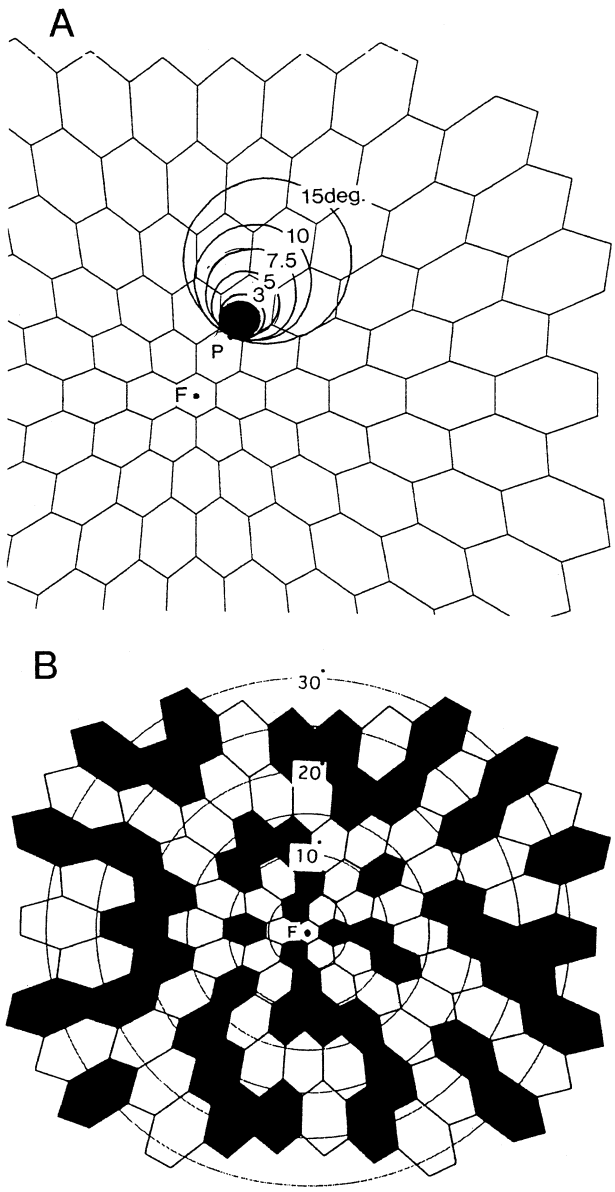

Figure 1. Stimulus location of six different sizes of artificial scotoma are indicated in (**A**) which is a part of the whole stimulus field on the CRT monitor (**B**).

were required to achieve this record (ie, 30 seconds per session). The evoked potentials were calculated and altered into the image of field topography using the Power Macintosh 7100/80 computer system (Apple Computer, Inc., Cupertino, CA, USA).

To make artificial scotomata of various sizes in the normal subjects, one of six different size of black circular papers was attached on the VERIS III CRT monitor, at the upper temporal portion, ten degrees apart from the fixation point (P in Figure 1A). The sizes of artificial scotomata subtend 2, 3, 5, 7.5, 10, and 15 degrees in a visual angle, respectively. Figure 1A shows the hexagonal elements in the central part of the whole stimulus field (Figure 1B).

M-ERGs were recorded from two patients with parafoveal retinal degeneration, and the results were compared with those of automated static visual field examination with a Humphrey Visual Field Analyzer (Humphrey Co., Ltd., San Leandro, CA, USA).

Results

M-ERGs recorded from a well-trained normal subject using various artificial parafoveal scotomata are shown in Figure 2. When the parafoveal scotoma size was within three circular degrees, the field topographies of M-ERGs revealed no decrease in response density. However, when the scotoma size exceeded 5 degrees, the scotoma was detected as a lower response density area, surrounded with an irregular, slightly higher-response density zone on the field topography. The shape of the scotoma is not circular. Similar findings were obtained from the other two normal subjects.

Case 1 is a 56-year-old male. His corrected visual acuities were 1.2 in both eyes. Left funduscopic examination revealed a retinal degeneration region (approximately 1.2 × 0.9 PD in size) which localizes 0.5 PD apart from the fovea to the temporal periphery (Figure 3A). Fluorescein angiography demonstrated hypofluorescence in this region.

The scotoma corresponding to the retinal region was detected in automated static perimetry, but no lower density area was recognized in the M-ERG as shown in Figure 5A. The location of the optic disc showed lower density.

Case 2 is a 64-year-old male. His corrected visual acuities were 0.8 in both eyes. The left fundus showed retinal degeneration (5 degrees in visual angle: 2.5 × 3.4 PD in size) in the temporal midperipheral region (Figure 3B). The automated static perimetry revealed a defect coincident with the location of the retinal degeneration (Figure 4B). The M-ERG obviously showed a decrease in response density for the nasal visual field defect (Figure 5B).

Discussion

Generally, it is considered very important to maintain good fixation during M-ERG recording.[1,3] Since parafoveal scotoma was applied in our experiment, good central fixation was maintained during the stimulation of the normal subjects. Our study shows that it is difficult for the VERIS III system to detect

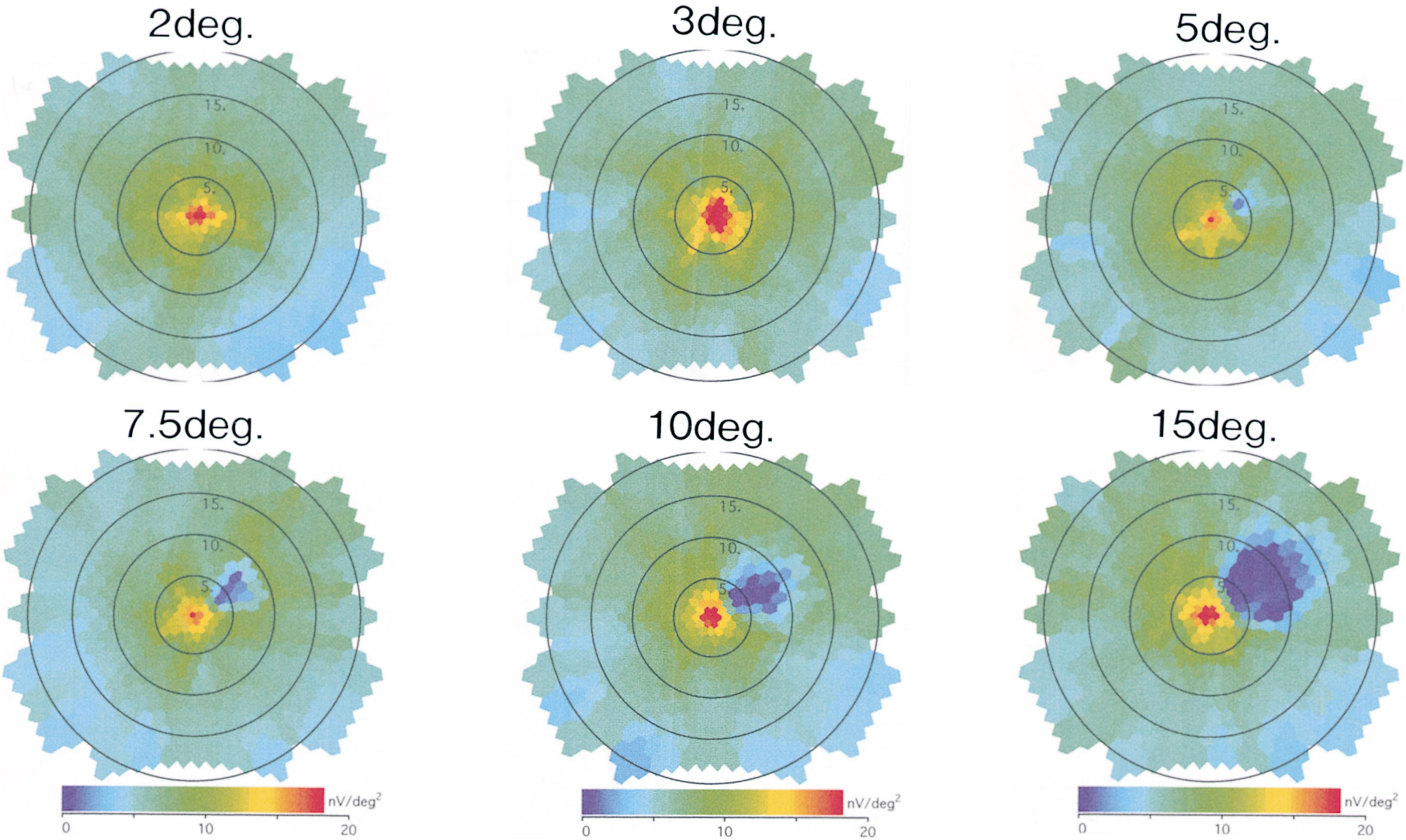

Figure 2. Field topographies of multifocal ERGs recorded from a normal subject to each artificial scotoma.

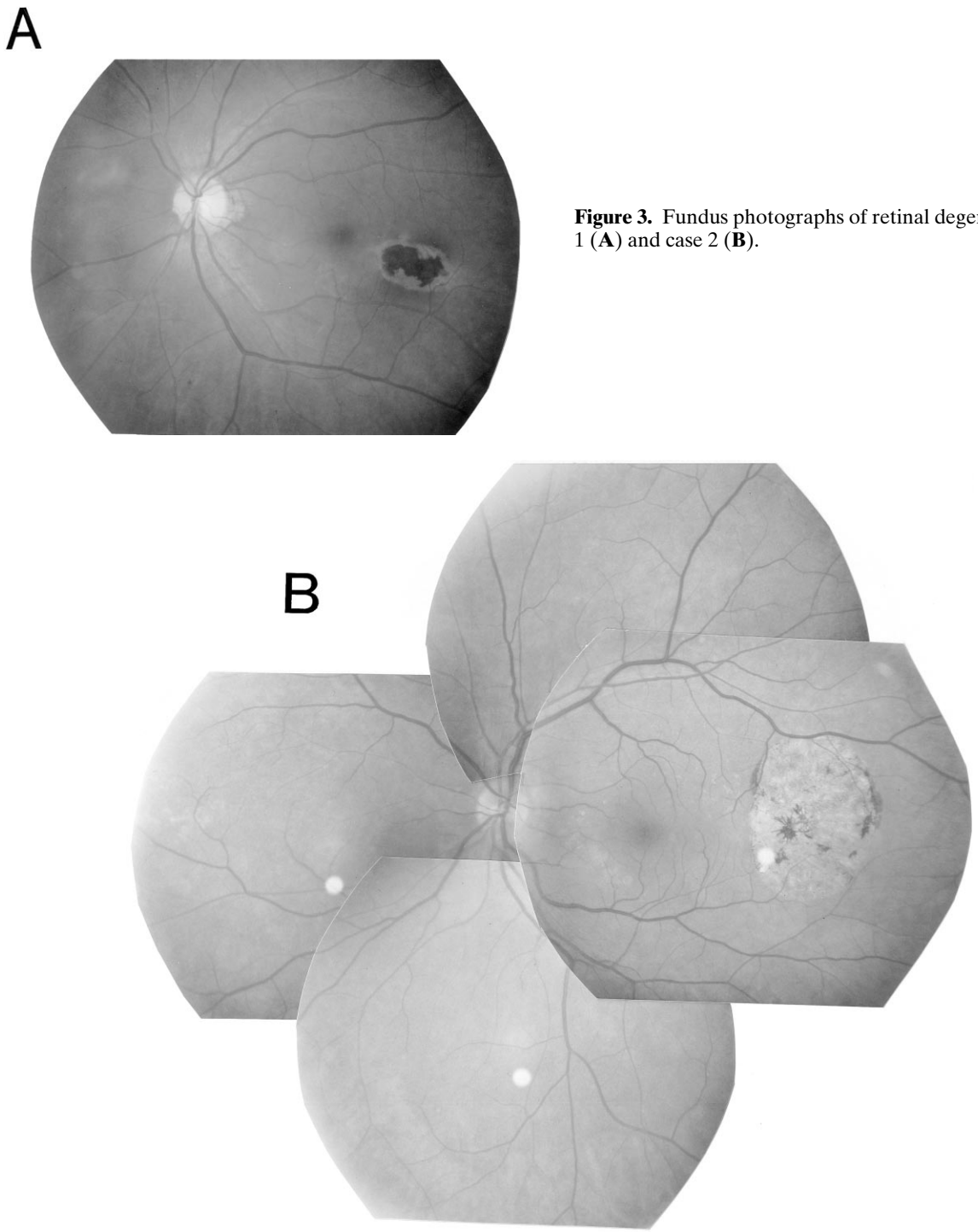

Figure 3. Fundus photographs of retinal degeneration case 1 (**A**) and case 2 (**B**).

parafoveal absolute scotomata within 5 degrees in size. This finding was confirmed in normal subjects as well as in two cases of retinal degeneration, and is attributed to the size of the stimulus hexagonal element which is equivalent to nearly 5 degrees in visual angle around the parafoveal region (Figure 1A). Bearse and Sutter[3] reported that focal ERGs were absent in the two of the stimulus elements that were not modulated in luminance during the recording. Their result coincides with our finding.

However, lower response density was observed for the optic disc in the field topography of case 1, al-

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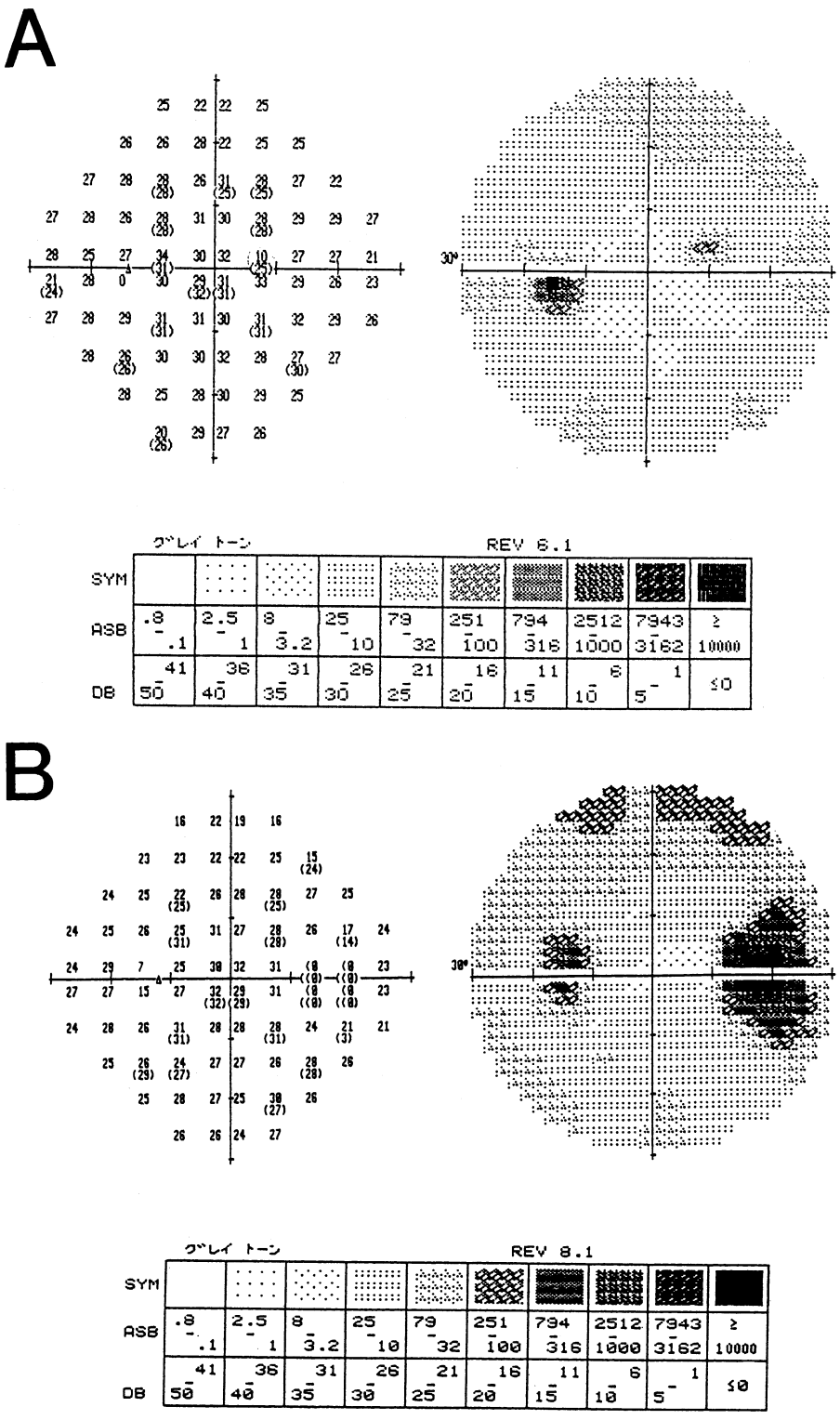

Figure 4. Humphrey visual fields of case 1 (**A**) and case 2 (**B**).

though the sizes of the optic disc and the patient's retinal degeneration were nearly the same. This may depend on what extent of the pathological region in the retina corresponds within a hexagonal stimulus element, even if the whole size of the retinal region is about 5 degrees in visual angle. When the retina region spreads over two hexagonal stimulus elements or more, it is possible that the field topogra-

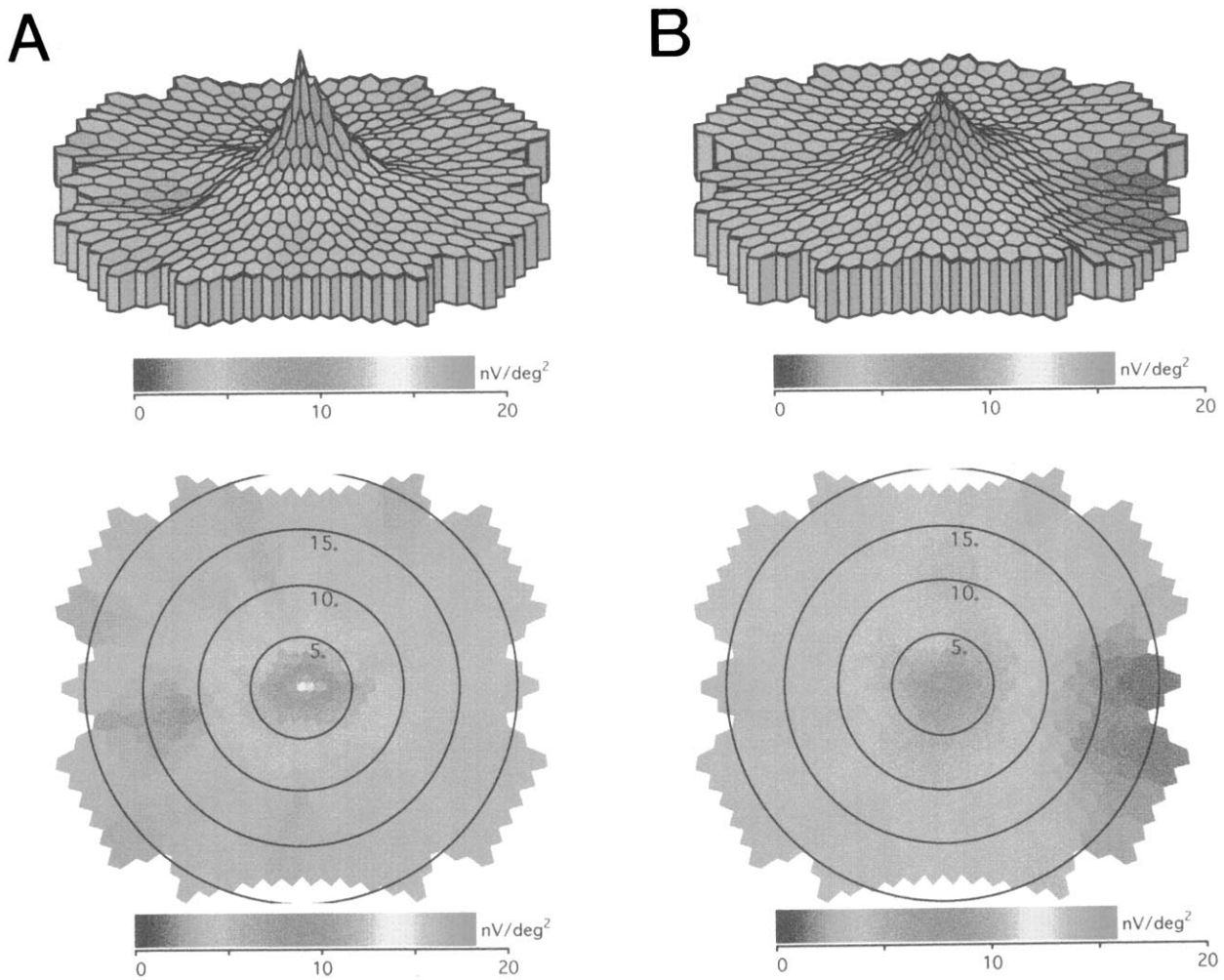

Figure 5. M-ERGs of case 1 (**A**) and case 2 (**B**). Upper: 3-dimensional color map; lower: field topography.

phy does not express lower response density for the retinal region if each part of the scotoma occupied within a stimulus element becomes small enough to produce a zone of lower response density.

The black circular paper for producing artificial scotoma is not always able to cover all the adjacent hexagonal elements. An element within the central part of the scotoma is covered completely, whereas other elements near the peripheral zone of the scotoma are covered in part. Therefore, the ratio of the region covered by the black paper and that uncovered on a stimulus element is different for each element site at the margin of the black circle. Therefore, the shape of absolute scotoma is not identical with that of lower response density region on the field topography of M-ERG, and the shape tends to be oval.

The results of these two cases of retinal degeneration were in accordance with our basic data from normal subjects. The M-ERG could not detect topographic localization when the scotoma size was within 5 degrees in visual angle and located in the parafovea. It will be necessary to establish smaller stimulus elements to detect smaller scotomata using this M-ERG system.

A part of this study was reported at the 34th meeting of the International Society for Clinical Electrophysiology of Vision.

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