Recording Multifocal Electroretinograms With Fundus Monitoring

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Purpose. To record multifocal electroretinograms (ERGs) with simultaneous fundus monitoring.

Methods. An infrared television fundus camera was used to monitor the fundus. A tightly packed array of 19 yellow light-emitting diodes (LEDs) was used as the stimulus source and LEDs were alternated between on and off according to a binary m-sequence at a rate of 75 Hz. The stimulus array subtended approximately 25° of the visual angle. Multifocal ERGs were recorded with a Burian–Allen bipolar contact lens electrode from two normal subjects and a patient with macular dystrophy.

Results. When the center of the stimulus was positioned on the fovea, the amplitude of the response was largest at the fovea and decreased toward the peripheral retina; the response pattern corresponded to the spatial distribution of cone cells. When the center of the stimulus was positioned on the optic disc, the response at the optic disc was undetectable. A reliable multifocal ERG was obtained from a patient with macular dystrophy.

Conclusions. This system made it possible to monitor the stimulus on the fundus and to adjust the stimulus to the correct retinal locations with exact focusing. The authors’ findings indicate that this method especially can be useful in patients with poor fixation. In addition, the authors’ results suggest that the stray light effect in the multifocal stimulus system is minimal if any. Invest Ophthalmol Vis Sci. 1997;38:1049–1052.

The multifocal electroretinogram (ERG) is a new, noninvasive technique designed to provide an objective assessment of retinal function. With this technique, a large number of retinal locations can be stimulated simultaneously and local responses can be extracted independently in a single recording session. High-resolution topographic mapping of retinal function also is possible with the local ERGs.

However, this test requires subjects to fixate a small spot on the stimulus monitor for several minutes. Therefore, results may be unreliable in subjects with fixation problems, such as young children, suspected malingers, and patients with eccentric fixa-

tion. Alternative approaches that can monitor the stimulus on the fundus are needed in these subjects. We recorded multifocal ERGs with fundus monitoring using an infrared television fundus camera in normal subjects and a patient with unstable fixation.

METHODS. Observation and Stimulus System. An infrared television fundus camera (Canon [Tokyo, Japan] CR-45NM) was modified to obtain the Maxwellian view focal system. Our system can monitor the fundus on the television screen at a 45° visual angle (Fig. 1). A tightly packed array of 19 yellow light-emitting diodes (LEDs) was used as the stimulus source. The LEDs were separated from each other by thin stainless-steel tubing and mounted on the side of the infrared television camera. The stimulus light was bent with a mirror and transmitted to the subject’s eye through the contact lens electrode. The position of the stimulus on the fundus can be moved by the examiner. The stimulus array subtended approximately 25° of the visual angle. The same element size was used at all locations. LEDs were alternated between on (stimulus duration, 5 msec) and off according to a binary m-sequence at a rate of 75 Hz. A same m-sequence (215–1), was used in each LED, but this sequence is lagged by different lengths for each location. This stimulus sequence was based on that used with a conventional multifocal system (VERIS, EDI, San Mateo, CA). A tungsten lamp provided constant background illumination. The intensity of stimulus light and background illumination was 45 cd/m² and 10 cd/m², respectively. The fundus and stimulus array were photographed simultaneously using 35-mm film.

Recording System. A Burian–Allen bipolar contact lens electrode, which allows clear observation of the fundus with a fundus camera, was used to record the ERG. The ground electrode was attached to the ipsilateral earlobe. The subject’s pupil was dilated fully with a combination of 0.5% tropicamide and 0.5% phenylephrine hydrochloride. A patch was placed over the contralateral eye. The total recording time was 8 minutes, and this 8 minutes was divided into 16 segments. The raw signal was amplified (Grass [West Warwick, RI] RPS-107) with the low- and high-frequency cutoffs at 10 and 300 Hz. The data collection and analysis were performed by the VERIS software (EDI). Extration of local ERG using a binary sequence has been described in detail by Sutter and Sutter and Tran.

Subject. Two of the authors (MK and AT) served as normal subjects. Except for refractive errors of −1.00 and −3.00 diopters, no opthalmologic or neurologic abnormalities were present. All data presented here are from the left eye of one subject (MK). Data from the second subject confirm those from the first. The left eye of a 38-year-old man with macular dystro-
RESULTS. Stimulation of the Macula. When the stimulus was positioned on the subject's fovea, the amplitude of the response was largest at the central retina, with decreased responses observed toward the peripheral retina (Fig. 2). The waveforms consisted of both triphasic early components and small later components, which essentially were similar to the waveform pattern obtained with conventional multifocal ERG. The implicit times of each component were slightly longer than those recorded with a conventional method. This longer implicit time could be presumably caused by both the lower stimulus intensity (45 cd/m²) than with the conventional system (120 to 200 cd/m²) and the longer effective exposure duration of 5 msec versus 1 msec or with the fast phosphor screens.

Stimulation of the Optic Disc. In the second session, the stimulus was positioned on the optic disc (Fig. 3). When the subject's gaze moved, he was reminded to keep his gaze in the proper position. The examiner continuously adjusted the center of the stimulus so that it fell on the optic disc. The response at the optic disc was undetectable. Small but detectable responses were recorded at the retina around the optic disc. A large response was obtained near the fovea.

CASE REPORT. A 38-year-old man had macular dystrophy of unknown category in both eyes. Visual acuity was 20/200 in both eyes. Fundus examination results showed atrophic patches and yellowish deposits in his macula; however, the optic disc and retinal vessels appeared normal (Fig. 4). Although full-field ERGs showed normal amplitudes in both rod and cone components, focal macular ERG recorded with a 15°-diameter spot at the macula was decreased severely. The current system was used because the patient could not see the fixation spot on the stimulus monitor of the conventional multifocal ERG. The examiner continuously adjusted the center of the stimulus on the fovea during recording, although the patient's fixation was unstable. The multifocal ERG obtained from his left eye was shown in Figure 4. When compared to normal data, ERG at the central retina markedly was reduced, whereas ERGs at the parafoveal retina moderately were reduced.

DISCUSSION. We successfully recorded multifocal ERGs with fundus monitoring using a modified infrared television fundus camera. We were able to monitor the exact location of the stimulus on the fundus and to adjust the stimulus to the correct retinal location.
location. The system used in the current study may yield more reliable results in patients with unstable fixation than a conventional multifocal ERG system, which requires subjects to fixate on the small spot on the stimulus monitor.1-4

Another advantage of the current system is that no optical lens is needed for the subject's eye to get the exact focusing of the image. With a conventional system, the subject's vision has to be corrected after insertion of the contact lens electrode. This procedure takes a few minutes to complete, and the edge of lens often interferes with the test field. In addition, the lens may influence the magnification of the stimulus spot. In the current system, we used a Maxwellian view system, which allows the examiner to focus objectively by moving a joystick and to magnify the stimulus spot on the fundus at a constant rate.

When the macula was stimulated, the amplitude of the focal cone ERG was largest at the fovea and decreased toward the peripheral retina. The response at the optic disc was undetectable, indicating that the stray light effect was minimal with our system. These findings are consistent with the previous results, using conventional focal ERG.7,9,10

The amplitudes of responses at the retina around the optic disc were rather small, presumably because cone densities in this area are low. This findings suggest that larger elements should be used for peripheral stimulation. In conventional multifocal ERG systems, the size of stimulus elements are scaled with eccentricity to produce approximately equal signal amplitudes at all locations.1-3

A disadvantage of our system is that only 19 retinal locations can be tested, whereas conventional systems can test more than 100 locations. Therefore, a large number of LEDs or another stimulus source is needed.

![Figure 3](image1.png)

**FIGURE 3.** (A) Stimulus positioned on the subject's optic disc. (B) Multifocal electroretinogram.

![Figure 4](image2.png)

**FIGURE 4.** (A) Fundus photograph from the left eye of a patient with macular dystrophy. (B) Multifocal electroretinogram.
for topographic mapping. Although further modifications of the system and clinical evaluation of its usefulness are needed, this preliminary study indicates that multifocal ERGs with fundus monitoring are feasible. This method may be useful for evaluating retinal function in patients with fixation problems.

**Key Words**

fixation problems, fundus monitoring, light-emitting diode, macular dystrophy, multifocal electroretinogram

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