New electroretinography technique for macular function evaluation using focal stimulation and fixation monitoring

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Abstract- This paper presents a new technique for the clinical evaluation of the macular function with electroretinography (MERG). Solutions have been developed for the focal stimulation of a specific retinal area, for the automated monitoring of patient fixation and for the recording of MERG responses.

I. INTRODUCTION

The electrophysiological examination of local structures of the retina would be of great interest for the ophthalmologist as it would provide objective information on pathological processes such as macular degeneration. In this paper, new solutions are proposed to the problems which have impeded the use of local electroretinographic examinations in the clinic. Results from the evaluation on normal subjects are also presented.

II. METHODOLOGY

A. Local Stimulation

One major problem in MERG examinations is to obtain a selective stimulation of a specific area of the retina. The use of local flashes of light is not a suitable solution because light scattering within the ocular media produces a simultaneous stimulation of peripheral areas of the retina. This light diffusion problem becomes very acute for the population of patients which is the most relevant for this type of examination, as the incidence of macular degeneration increases with age and with opacification of ocular media. After 60 years of age, more than 50% of the light entering the eye is not directly projected to the retina [1,2] and contributes by almost the same amount to the global electroretinographic response. This problem is solved by the use of a pattern stimulation made of a checkerboard including 4 square elements viewed individually under an angle of 5 degrees. The reversal of this pattern produces a local light stimulation and a constant amount of stray light avoiding ERG responses from the peripheral retina. The large size of the pattern minimizes the influence of diffusion and refraction errors on the contrast of the retinal image.

B. Fixation Monitoring

The MERG response is only a few micro volts in amplitude.

In order to obtain a reliable response, it is necessary to use signal extraction techniques over a period of time lasting about 60 seconds.

Fixation stability during such a long period of time is difficult for patients who suffer from central vision alterations. A solution based on coupled direct visualization and stimulation of the fundus have already been proposed [3]. However, this solution requires a great amount of manual skill and the reaction time of the operator to eye movements is too long.

Therefore, an automated monitoring of fixation has been preferred. It is based on the measurement of the relative positions of corneal reflex and pupil from images of the eye obtained from a near infrared camera [4] (Fig. 1.). This technique allows measurements of gaze orientation with an absolute precision of ±1 degrees, without interference of head movements. Rejection algorithms have been implemented which eliminate MERG responses when the gaze orientation deviates from the fixation axis by more than a given threshold. A warning sound is also generated as a feedback to the patient and to the operator.

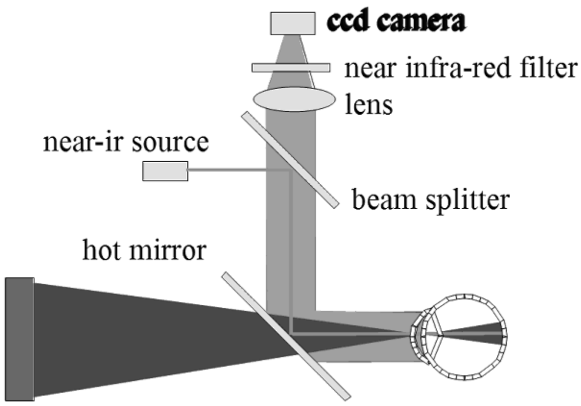


Fig. 1. optical set-up of the examination system for macular ERG

C. Bioelectric Responses Recording

An ideal electrode for MERG should not interfere with the optical quality of the retinal image and should provide a reliable and artefact free MERG response. Several electrodes have been designed to meet these goals : The "Goldfoil" [5] is based on a strip of mylar coated with gold, in contact with the corneal margin of the sclera. The "DTL fiber" [6] is made of micro fibers of nylon, 50 □m in diameter, impregnated with silver and inserted in the lower fornix. The "carbon fiber" electrode is built from a carbon fiber, coated with electrically insulating plastic foils except at its extremities. It is shaped as a hook which can be easily placed in the lower fornix

III. CLINICAL EVALUATION

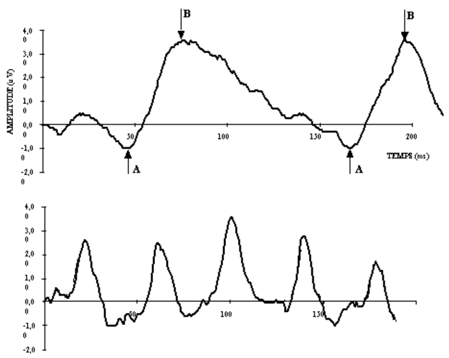
This part of the study is aimed at defining the optimal examination parameters. This evaluation has been performed with a Vision Monitor System (Metro-vision, France), including a cathode ray tube stimulator, bioelectric amplifiers and an eye movement recording apparatus.

7 normal subjects (total of 14 eyes) have been tested.

A. Stimulation Parameters

A cathode ray tube stimulator is used to generate the checkerboard pattern. A compromise has to be made between the size of the stimulated area and the local information provided by the MERG response. 1 □V is the minimum response amplitude detectable under clinical conditions. An average 4 □V response is obtained from the group of normal subjects when the stimulator screen is viewed from a distance of 2.0 m, which corresponds to a 10 degrees stimulated area.

Another compromise is also to be made between the stimulation frequency and temporal information. When the stimulation frequency is increased, the signal waveform becomes sinusoidal, which permits more efficient filtering techniques but results in a loss of information on the components originating from different layers of the retina (Fig. 2.).



6.25 Hz stimulation

25 Hz stimulation

Fig. 2. macular ERG responses versus stimulation frequency

A 6.25 Hz stimulation frequency is found to be an optimal compromise. Other stimulation parameters are the maximum luminance set at 70 cd/m^2 and the contrast at 98%. The subjects' pupils must be dilated in order to eliminate variations of retinal illuminance.

B. Recording parameters

Three types of active electrodes have been tested : the "Goldfoil", the "DTL fiber" and the "carbon fiber". The "carbon fiber" electrode provides a better signal-noise ratio and a reduced sensitivity to blinking artefact, as needed for the acquisition of reproducible MERG responses. It is also free from corneal abrasion problems.

C. Fixation Monitoring

Fixation monitoring with a rejection threshold of 2 degrees is found to be suitable for all subjects. In a large number of subjects, the examination must be performed with monocular viewing in order to avoid large fixation errors due to phoria. The fixation monitoring system also provides a measurement of the pupil size which has been used as an early detection of blinking which produce large artefacts in the ERG signal.

IV CONCLUSION

This new technique for recording macular ERG has been found to provide reliable responses in all the 14 normal eyes which were tested. These results are mainly due to the use of an automated fixation monitoring which eliminates responses variations due to eye fixation errors and to blinking artefacts. Further work is under way for the evaluation of this technique on pathologic subjects.

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