Objective: To examine results of the multifocal electroretinogram (MERG) after spontaneous resolution of central serous chorioretinopathy (CSC) detachments.

Methods: Multifocal electroretinograms were recorded from both eyes of 5 recovered patients with CSC and 10 age-matched healthy subjects. All patients with CSC had bilaterally subnormal MERG amplitudes during a first attack of CSC occurring 7 to 23 months earlier.

Results: After recovery from CSC, MERG A-wave and B-wave amplitudes increased markedly where the detachment resolved, and moderately elsewhere in the posterior pole of both eyes. However, the signals from both eyes remained either subnormal or low-normal relative to controls. Multifocal electroretinogram B-wave latencies improved from prolonged to mid-normal values in both eyes.

Conclusions: Both eyes of patients with active unilateral CSC exhibit diminished MERG amplitudes. Although MERG response amplitudes increased modestly after recovery from CSC, they remained statistically subnormal throughout the posterior pole of both eyes. These findings support the theory that subretinal fluid retention in CSC is secondary to diffuse pathologic changes in the choroid and/or retinal pigment epithelium. They also suggest that the underlying or predisposing abnormalities of CSC resolved only partially in our patients. Components of the MERG may have value as a prognostic tool for judging the risk of developing symptomatic CSC.

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CENTRAL SEROUS chorioretinopathy (CSC) is a disease of unknown pathogenesis in which fluid enters the potential space between the retinal pigment epithelium (RPE) and the photoreceptors. Fluorescein angiography shows a focal source of dye leakage into the area of fluid accumulation. Individuals with high-stress lifestyles and “Type A” personalities are most often affected, and men are more frequently affected than women. There is an increasing body of clinical and experimental evidence that the retention of fluid that enters from a focal leak is secondary to an underlying diffuse choroidal or RPE dysfunction. For instance, the fellow (unaffected) eye often shows abnormalities of the RPE and may sometimes develop a serious detachment. Areas much larger than the locus of detachment have shown choriocapillary insufficiency and capillary hypoperfusion using indocyanine green angiography. Multifocal electroretinography (MERG) during active disease has demonstrated subnormal macular cone responses broadly in the posterior pole of both the affected and fellow eyes. Experimental work has shown the RPE to be so efficient at removing subretinal fluid that fluid is not likely to accumulate from a small focal leak if the surrounding RPE is healthy. Finally, animals given repeated systemic injections of adrenaline and corticosteroids have developed multifocal serous detachments.

To the extent that changes in the MERG reflect underlying pathologic changes in the choroidal vasculature and/or RPE, the MERG may provide a clinical index of susceptibility to detachment in CSC. However, further information is needed to determine which MERG parameters are most indicative of the active state of CSC, and whether these parameters change in relation to clinical findings. Two previous studies looked at the focal electroretinogram (ERG) from the central macula of affected eyes with CSC after the resolution of detachments and found variable degrees of ERG recovery between 2 weeks and 5 months. We are not aware of any comparable studies using the
SUBJECTS AND METHODS

SUBJECTS

Five patients studied previously with MERG recordings during an initial (and only) episode of unilateral CSC were reexamined (Table 1). None of the patients had significant abnormalities in the fellow eye at initial examination. Two were women and 3 were men; their ages ranged from 37 to 52 years (mean age, 42 years). All of the patients were in good general health, and none were taking corticosteroids. Subject 2 had Reiter syndrome, for which he used nonsteroidal anti-inflammatory medications and misoprostol. In all subjects, the initial serous detachments resolved without laser photocoagulation between 1 and 3 months after initial visit. Follow-up MERGs were recorded 7 to 23 months after the initial visit, and no less than 4 months after the resolution of fluid. Visual acuity at the time of this study was 20/23 or better in both eyes, and fundus examination revealed no serous detachments. There were no RPE alterations other than mild granularity in the affected eyes, but the fellow eye of subject 5 had developed 2 tiny pigment epithelial detachments temporal to the macula.

Ten control subjects of similar age (age range, 31-55 years; mean age, 40 years) had an MERG recorded during the course of this study. All were in good general health, with 20/20 OU visual acuity and no evidence of retinal disease. The tenets of the Declaration of Helsinki were followed, and all subjects gave written informed consent following a full explanation of procedures.

MERG RECORDING

Multifocal electroretinogram recordings were obtained with a VERIS instrument (Tomey Corp, Nagoya, Japan) and analyzed using the VERIS Science software (Electro-Diagnostic Imaging Inc, San Mateo, Calif) developed by Sutter and Tran.10 The stimulus consisted of an achromatically flickering 103-hexagon array with an average photopic luminance of 100 candelas (cd)/m². Each subject was refracted using spectacle lenses and adjusted to the appropriate viewing distance. Room lights were dimmed so that luminance was approximately 1 cd/m² at a calibration spot 6 in (15.2 cm) from an off-white wall.

Patients’ pupils were fully dilated with 1% tropicamide and 2.9% phenylephrine hydrochloride and corneas were anesthetized with 0.5% proparacaine hydrochloride. The MERG of each eye was recorded with the same Burian-Allen electrode (Hansen Instruments Inc, Iowa City, Iowa). The MERG recording time was 7 minutes and 17 seconds, divided into eight 54.6-second intervals.

DATA ANALYSIS

Signals were band-pass filtered (3-300 Hz) and amplified using a gain of 10 (Amplifier Model 12C; Grass Instrument Co, Quincy, Mass). Each MERG data file was run once through an artifact rejection process included in the software, and responses were density scaled to account for variation in hexagon area. To compare MERG waveforms at different eccentricities within the macula, data were averaged from 6 concentric rings of MERG responses from the fovea outward to 20°. The negative and positive deflections of the MERG waveform will be referred to as A- and B-waves, respectively, as they are generally analogous to the A- and B-wave components of a full-field ERG.11

The MERG data from our previous report,6 during the active phase of CSC, included 2 recordings made with 241 stimulus hexagons. To obtain averages that incorporate these data with the data from recordings made with 103 hexagons, the 241-hexagon waveforms were grouped into 6 concentric rings that approximated the eccentricities of the 6-ring groupings used with 103-hexagon arrays. Since the eccentricities are not exactly equal, we used weighted averages of the 103- and 241-hexagon array ring eccentricity values on the x-axis when plotting these results from the active phase of CSC.

Differences between the means of controls and CSC patients were evaluated statistically using the 2-tailed Student t test, with P<.05 considered statistically significant. These results are presented in Table 2, whereas the figures show a range (envelope) of values from our control subjects.

Table 1. Characteristics of Patients With CSC*

<table>
<thead>
<tr>
<th>Subject No./Sex/Age, y</th>
<th>VA During Active CSC</th>
<th>VA After Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/F/40</td>
<td>20/20</td>
<td>20/20</td>
</tr>
<tr>
<td>2/M/52</td>
<td>20/20</td>
<td>20/25</td>
</tr>
<tr>
<td>3/M/37</td>
<td>20/15</td>
<td>20/20</td>
</tr>
<tr>
<td>4/M/57</td>
<td>20/50</td>
<td>20/20</td>
</tr>
<tr>
<td>5/F/42</td>
<td>20/30</td>
<td>20/20</td>
</tr>
</tbody>
</table>

* CSC indicates central serous chorioretinopathy; VA, the corrected visual acuity of the affected eye.

Table 2 shows averaged MERG waveform parameters (A-wave amplitude, B-wave amplitude, and B-wave latency) at different eccentricities from the fovea, before and after recovery from CSC. The A-wave and B-wave amplitudes improved markedly after recovery in the area of detachment (approximated by the center 2 rings of the affected eye), and to a moderate degree elsewhere in the posterior pole of both eyes. Even after recovery, the MERG amplitudes in both eyes remained statistically subnormal (relative to controls) at most of the eccentricities.

These A-wave and B-wave amplitude data are shown graphically in Figures 1 and 2 to facilitate the comparison of prerecovery and postrecovery signals relative to the envelope of normal values. Values are plotted on a log scale so that the range of normal values is similar in the central and peripheral areas of the macula. There

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is an improvement after recovery but also a persistence of subnormal or borderline amplitude at all eccentricities of the posterior fundus. The effect of the detachment during the active phase of disease is evident in affected eyes as a dip in A-wave and B-wave amplitudes at 0° and 3.5° eccentricity. After recovery, the amplitudes in this central area returned to a level comparable with the fellow eye.

The changes in MERG B-wave latency with recovery are shown in Table 2 and Figure 3. During active disease, the average latencies were significantly prolonged (although just outside the normal range) in both affected and fellow eyes. After recovery, both eyes showed response latencies in the middle of the normal range.

Table 3 presents MERG results in relation to patient age and to the time between the resolution of detachment and the final MERG. No obvious correlations are seen, but the sample is too small to draw firm conclusions.
Our results show that local ERG responses improved after resolution of clinical CSC, but remained borderline or subnormal in amplitude throughout the posterior pole of both affected and fellow eyes. As might be expected, the greatest improvement occurred in the area of the detachment (the central retina of affected eyes). However, the persistence of MERG recording abnormalities beyond the area of detachment and in the fellow eye is consistent with the concept that CSC is pathophysiologically a diffuse rather than a focal disorder, and suggests that some of these pathological changes can persist even after resolution of the detachment.

We are unaware of any other ERG studies that have differentiated between regions of the macula in CSC, or followed abnormalities in the fellow eye of CSC patients. Nagata and Honda, using a 4° stimulus spot to record a focal ERG, found persistent low amplitudes in affected eyes 2 to 7 weeks after xenon arc photoagulation and resolution of the detachments. Miyake et al, using a 10° stimulus spot, observed recovery of focal ERG B-wave amplitudes and latencies 2 to 5 months after recovery from CSC. However, the macular oscillatory potentials remained subnormal. Our results show that the A-wave and B-wave amplitudes, which were initially reduced broadly across the posterior pole of both eyes, improved in both eyes after resolution of the detachment, but not to normal. While close comparison between these studies is difficult because of methodological differences, they are consistent to the extent that there seems to be both some degree of recovery and some degree of persistent abnormality in the affected macula after the resolution of fluid.

Since the ERG abnormalities we have observed involve both the A wave and B wave, the retinal changes must originate at the level of the photoreceptors. It is possible that systemic factors such as adrenergic and corticosteroid activity are affecting the photoreceptors directly. However, we suspect that this photoreceptor dysfunction reflects alterations in the underlying choroidal vasculature and/or RPE, although there is no multifocal test of RPE function available to confirm this directly. We have postulated elsewhere how factors such as adrenergic and corticosteroid stress can alter choroidal vascular function and secondarily (if not primarily) diminish the water transport capability of the RPE, creating a susceptibility to subretinal fluid accumulation that results in CSC. Our previous study of the active stage of CSC showed that MERG abnormalities were diffuse and bilateral, which supports the concept that the disease represents broad dysfunction of the choroid and RPE rather than just a focal event (such as a leak). The present data lend further support to this view. On one hand, the MERG responses (which represent a broad area of macular dysfunction) changed in accordance with the clinical course of disease (they improved with recovery). On the other hand, a degree of MERG abnormality remained, which is not surprising since many of the stress factors or other systemic causes that affect CSC patients are likely to persist even after the attack.

The MERG may in time prove useful in assessing the degree of susceptibility to a CSC attack, especially in high-risk patients with stressful lifestyles, patients using corticosteroids, or patients with a history of prior attacks. It may also aid in determining whether or not drug treatment or stress reduction can reduce the predispo-

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Table 3. MERG Response Parameters Relative to Clinical History*

| Subject No./Age, y | Time of Final MERG, mo After Resolution of CSC | Composite Macular B-Wave† Amplitude, nV/deg² Latency, ms During CSC After Resolution During CSC After Resolution |
|-------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|
| 1/40              | 4                                           | 22.9                                        | 33.3                                        | 30                                         |
| 2/52              | 16                                          | 15.8                                        | 35                                          | 29.2                                       |
| 3/37              | 20                                          | 14.9                                        | 30.8                                        | 30                                         |
| 4/37              | 7                                           | 11.5                                        | 35                                          | 30                                         |
| 5/42              | 23                                          | 21.4                                        | 35                                          | 30.8                                       |
| Healthy‡/40       | NA                                          | 26.6                                        | 29.7                                        | 29.7                                       |

*MERG indicates multifocal electroretinogram; CSC, central serous chorioretinopathy; NA, not applicable.
†Values are the composite average of all MERG responses.
‡Values are the average of the healthy subjects.
sition to detachment. However, further studies are needed to determine which parameters (eg, MERG amplitude or latency) are most relevant. The results from this study suggest that the finding of increased B-wave latency, along with reduced A-wave and B-wave amplitudes, might turn out to be the most useful measure of clinical risk. Reduced MERG amplitudes persisted during clinical remission, but reduced amplitudes in combination with waveform delays were observed only during the active phase of the disease. This proposal remains hypothetical since we have not yet observed any recurrent detachments, our patient sample is small, and we have not had the opportunity to follow patients over longer periods to find out whether full recovery of the MERG amplitudes might eventually occur.

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REFERENCES


A look at the past . . .

As most of the failures in cataract extraction in recent years are in one way or another due to the lack of control of the opening in the cornea during the operation, or to its accidental opening afterwards, the use of the suture has naturally suggested itself to surgeons, some of whom have reported encouraging results . . .

Dr. H. W. Williams, of Boston, was the first operator to practise suture of the cornea after cataract extraction in man. He reported forty-eight cases in 1867 with 4 per cent. of iris prolapse and no case of suppuration. His needle was 6 mm long with flat cutting points. It was held with forceps. The suture consisted of a single strand of fine silk. This was inserted after the removal of the lens. It did not enter the anterior chamber, but passed through the superficial edges of the incision.

He advocated the removal of the suture in a week or less. He claimed that he had fewer accidents at the time of the operation and better healing of the wound than when the suture was not used. In a communication two years later, he adds to the description of his method the following: “At present I am disposed to extend the corneal flap at its apex a little way into the conjunctiva, so as to allow of the placing of the suture in this membrane, where it is more readily inserted than through the tougher corneal tissue.”