Focal Macular Electroretinogram in X-Linked Congenital Retinoschisis

Yozo Miyake, Noriyasu Shiroyama, Ichiro Ota, and Masayuki Horiguchi

Purpose. To study macular function of X-linked congenital retinoschisis (CRS) by focal macular electroretinogram (MERG).

Methods. MERGs were recorded with 5°, 10°, and 15° spots in 20 patients with CRS. Seventeen patients showed foveal schisis with little or no change in foveal fluorescein angiography (Group 1), and three patients showed advanced macular changes with nonspecific macular degeneration (Group 2).

Results. In Group 1, a-wave amplitudes were within the normal range, but b-waves and oscillatory potentials (OPs) had mean amplitudes significantly below those for normal control subjects. The mean b- to a-wave ratios, significantly lower than in normal eyes, decreased significantly with decreasing spot size. The implicit times of a-waves, b-waves, and OPs were significantly delayed. In Group 2, MERGs were nearly nondetectable.

Conclusions. The macular pathology of CRS exists mainly in the middle and inner retinal layers, disturbing the fovea more than the perifovea, whereas degeneration of photoreceptors progresses in more advanced stage. Invest Ophthalmol Vis Sci. 1993;34:512-515.

X-linked congenital retinoschisis is present at birth or soon after in males.1 The retinoschisis is characteristically foveal, presenting biomicroscopically as small, superficially located cysts arranged in a stellate pattern and radial striae centered in the fovea.1,2 Fifty percent of patients present evidence of peripheral retinoschisis as well.1 Histopathologically, the splitting in congenital retinoschisis occurs in the nerve fiber layer.3-5 Yanoff and associates3 postulated that the defect is in the Müller cells. The full-field electroretinogram (ERG) always shows a lower-than-normal amplitude ratio of b- over a-waves (b/a ratio) and a reduced amplitude of oscillatory potentials (OPs).1,2,6,7 These findings, which indicate widespread functional abnormality of the middle retinal layer (where b-waves and OPs originate), are observed even in patients whose clinically visible abnormality in the fundus is limited to the macula. Except for Deutman's brief description of subnormal foveal electoretinographic results,1 little is known about focal ERG findings in the macula, where an ophthalmoscopic abnormality is almost always present. Using our previously reported method for obtaining focal macular ERG (MERG),8,9 we studied macular function in 20 patients with X-linked congenital retinoschisis.

PATIENTS AND METHODS

Twenty eyes of 20 male patients with X-linked recessive congenital retinoschisis were divided into two groups. In Group 1 (17 eyes of 17 patients) the macula showed foveal schisis, and fluorescein angiography revealed minimal or no change in the retinal pigment...
epithelium in the macular region. Associated peripheral schisis, noted in four of the 17 eyes, did not involve the posterior pole. The patients were 8-32 yr old (mean, 14.2 yr). Corrected visual acuity of the examined eyes ranged from 0.2–0.8 (mean, 0.42). In Group 2 (three eyes of three patients), the macula showed nonspecific degeneration, and two of the three eyes showed pigmentation of the peripheral fundus (infero-temporal quadrant). Fluorescein angiography of the macula in these patients showed hyperfluorescence, indicating degeneration of retinal pigment epithelium. The patients were 60, 66, and 72 yr old, and visual acuities were 0.02, 0.04, and 0.1, respectively.

Our system for recording MERG under infrared television fundus monitoring has been described previously. After the patient's pupils were fully dilated with a combination of 0.5% tropicamide and 0.5% phenylephrine hydrochloride, MERGs were recorded with 5 Hz rectangular stimuli with equal light and dark periods. Three stimulus spot sizes—5°, 10°, and 15° in diameter—were used. The spot was centered on the fovea, and 512 responses to each spot size were averaged by a signal processor. The changes in amplitude and implicit time of MERGs secondary to light adaptation during recordings were negligible, because the patients were light adapted for 20 min before testing by the room light (70 lux).

Tenets of the Declaration of Helsinki were followed. Informed consent had been obtained from all subjects and patients, and institutional human experimentation committee approval was granted.

**RESULTS**

Figure 1 shows MERGs in a normal subject (left) and in patients in Groups 1 and 2. Table 1 shows the mean (±SD) amplitudes of a-waves, b-waves, and OPs (O1 + O2 + O3), and the mean (±SD) b-wave and a-wave (b/a) ratio for the three different spot sizes in the 17 Group 1 patients and in 72 normal control subjects. Nonparametric statistical analysis using the Mann-Whitney test was done to determine the significance of the amplitude and implicit time in patients and normal subjects. For the patients, the mean amplitudes of b-waves and of OPs were significantly reduced ($P < 0.001$), whereas the mean amplitude of a-waves was not significantly different from normal control subjects.

![Figure 1](http://iovs.arvojournals.org/pdfaccess.ashx?url=data/journals/iovs/933397/)
TABLE 1. Mean Amplitude (±SD, in μV) of a-waves, b-waves, and Oscillatory Potentials (OPs) Elicited by Focal Stimuli of Different Sizes From Maculas of 72 Normal Subjects and 17 Patients With Congenital Retinoschisis (CRS; Group 1)

<table>
<thead>
<tr>
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<th>5°</th>
<th>10°</th>
<th>15°</th>
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<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>CRS</td>
<td>Normal</td>
</tr>
<tr>
<td>a-wave</td>
<td>0.46 ± 0.19</td>
<td>0.37 ± 0.21</td>
<td>1.19 ± 0.33</td>
</tr>
<tr>
<td>b-wave</td>
<td>1.27 ± 0.35</td>
<td>0.35 ± 0.22</td>
<td>2.88 ± 0.70</td>
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<tr>
<td>OPs</td>
<td>0.33 ± 0.19</td>
<td>NR</td>
<td>1.09 ± 0.38</td>
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<tr>
<td>b/a ratio</td>
<td>2.75 ± 1.05</td>
<td>0.95 ± 0.53</td>
<td>2.48 ± 0.68</td>
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NR, nonrecordable.

At all stimulus spot sizes, the mean b/a ratios were significantly smaller than normal (P < 0.001). Furthermore, the b/a ratio for the 5° spot was significantly smaller than that for 10° (P < 0.01), and the ratio for 10° was significantly smaller than that for 15° (P < 0.05). In normal subjects, there was no significant difference of b/a ratio between 5°, 10°, and 15° spots.

Table 2 compares the mean (±SD) implicit times of a-waves, b-waves, and OPs (O1, O2, O3) in patients and in controls. The mean implicit times in patients of Group 1 were significantly delayed (a-waves, P < 0.001; b-waves, P < 0.001; O1, O2, and O3, P < 0.01).

For the 17 eyes of Group 1, the b-wave amplitudes of 15 eyes (88%) and a-wave amplitudes of 2 eyes (12%) were lower than ±2 SD of normal when evaluated with a 10° spot. The a-wave amplitude of one eye was higher than ±2 SD of normal. The implicit times of the b-wave of 15 eyes (88%) were longer than ±2 SD of normal, as were the implicit times of the a-wave of 14 eyes (82%). The mean visual acuity of two eyes with significantly lower a-wave amplitude and longer implicit time was 0.39, whereas that of other eyes was 0.44.

Two of the three patients in Group 2 showed non-recordable macular response. One of them showed recordable response only with the 10° and 15° spots (Fig. 1). The amplitudes of a-wave and b-wave, and the b/a ratio of this patient, were significantly smaller than those of a normal control subject. The OPs were absent. The implicit times of the a- and b-waves with the 10° and 15° spots were significantly delayed.

DISCUSSION

Although the macular ophthalmoscopic findings in congenital retinoschisis is unique, the MERGs in Group 1 were similar to those usually observed in a full-field ERG in this disease: reduced amplitude of b-waves and OPs, low b/a ratio, and delayed implicit time of each component. The similar findings between full-field ERG and MERG indicate that the portion of the retina where retinoschisis is ophthalmoscopically absent has a functional disturbance similar to the macula. The disproportional decrease of b-wave compared with a-wave results in significantly lower b/a ratio in MERG. This finding and the decreased OP amplitudes indicate dysfunction of the middle and inner retinal layers of the macula (possibly the Müller cell dysfunction, as suggested histopathologically). The relatively good a-waves, which originate mainly in the photoreceptors, indicates relatively good photoreceptor (cone cell) function. Although the peak a-wave amplitudes of macular ERGs were approximately the

TABLE 2. Mean Implicit Time (±SD, in msec) of a-waves, b-waves, and Oscillatory Potentials (OPs) by Focal Stimuli of Different Sizes From Maculas of 72 Normal Subjects and 17 Patients With Congenital Retinoschisis (CRS; Group 1)

<table>
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<th>5°</th>
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<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>CRS</td>
<td>Normal</td>
</tr>
<tr>
<td>a-wave</td>
<td>23.4 ± 2.4</td>
<td>32.0 ± 7.3</td>
<td>21.6 ± 2.2</td>
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<tr>
<td>b-wave</td>
<td>45.8 ± 2.7</td>
<td>55.8 ± 7.1</td>
<td>43.0 ± 3.6</td>
</tr>
<tr>
<td>OPs</td>
<td>01</td>
<td>NR</td>
<td>02</td>
</tr>
<tr>
<td></td>
<td>27.0 ± 2.0</td>
<td>NR</td>
<td>26.2 ± 1.2</td>
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<tr>
<td></td>
<td>35.5 ± 1.9</td>
<td>NR</td>
<td>32.5 ± 1.4</td>
</tr>
<tr>
<td></td>
<td>39.7 ± 2.1</td>
<td>NR</td>
<td>39.0 ± 1.1</td>
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NR, nonrecordable.

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same in normal subjects and Group 1 patients (Table 1), the implicit times of the peak a-wave were delayed for the patients (Table 2), indicating that the a-wave and macular cones cannot be normal.10

The b/a ratio became significantly smaller as the size of stimulus spot decreased (Table 1), suggesting that the middle and inner retinal layer are more disturbed in the fovea than in the perifovea. Because the size of foveal schisis is approximately 5° to 10° in diameter, the region of foveal schisis may have more marked dysfunction of the middle and inner retinal layers. Our results support the psychophysical findings reported by Peachey et al8 that the sensory neural pathways outside the fovea operate better than the fovea.

In Group 2 patients, not only b-waves and OPs but also a-waves showed extreme reduction in amplitude, resulting in nonrecordable or barely recordable response. This result indicates that functional disturbance of the photoreceptors consistent with the abnormal retinal pigment epithelium revealed by fluorescein fundus angiography in Group 2 patients.

Key Words
b-wave to a-wave ratio, focal macular ERG, oscillatory potentials, photoreceptor function, X-linked congenital retinoschisis

References