Binocular visual field development was measured in 11 infants who had stage 3 ROP in early infancy and in 11 infants without ROP, matched for birthweight and gestational age. Kinetic perimetry was used to measure visual fields along the 45°, 135°, 225° and 315° half-meridia. Infants were tested at 4, 9, and 18 months from due date. Analyses of variance were used to compare results of the two groups for each age tested. Results at the 4-month test age indicated that both groups had visual fields within the normal range for their age. However, at the 9-month test age the ROP group showed a significantly smaller visual field than the control group. At 18 months, the ROP group still showed smaller visual fields than the control group, but the difference was not significant. The results suggest that dysfunction of the peripheral retina associated with ROP may produce a constriction of the visual field or a delay in visual field development.

Retinopathy of prematurity (ROP) is a disorder characterized by abnormal development of the retinal vasculature of preterm infants. In stage 3 ROP (ICROP), the blood vessels in the retinal periphery form a ridge with extension of fibrovascular tissue into the vitreous cavity of the developing eye. Most affected infants will develop normal central vision, but it is reasonable to suspect that peripheral visual function may be affected.

Two studies have examined visual fields in children who had ROP. Majima, using static and kinetic perimetry, found a significant reduction in peripheral retinal sensitivity in children with cicatricial disease, but not in children whose ROP had resolved without residua. Unfortunately, Majima did not correlate these findings with the active stages of ROP these children had as infants. Tamai and colleagues looked at several visual functions, including visual fields of children with ROP who had undergone cryocautery. They found that six out of the 11 infants tested had defects in their visual fields. Again, the active stages of ROP these children had as infants were not reported. Results from these studies suggest that infants who have ROP are at risk for defects in their peripheral vision. It is still not clear, though, how the acute phase of the ROP relates to later visual field development.

The purpose of this study was to measure visual field development in a group of infants who had stage 3 ROP during early infancy.
across directions, for the ROP and no-ROP groups at the three test ages. The visual field size increases with age in both groups. However, the increase appears to be slower for the ROP group than for the no-ROP group.

To investigate further the 9-month results, visual field deficits for individual infants were determined by comparing each infant's median scores along every test direction with normative data of healthy preterm infants. A deficit in visual field size was considered to be present if a value fell more than 2 SD below the mean of the healthy preterm group for each direction. Field deficits were found in three out of eight infants in the ROP group and in none of the infants in the no-ROP group. Eye exams obtained during the active phase of ROP were then examined to determine location of ROP in the retina. The eye exam results indicated that the three infants with visual field deficits had had more than 4 clock hours of stage 3 ROP located in the nasal retina. None of the infants whose stage 3 ROP had been located exclusively in the temporal retina showed field deficits.

**Discussion.** The results indicate that infants who have ROP early in life can have a decrease in visual field size as measured in later infancy. It would be of considerable interest to know whether the visual field deficits shown by these infants were due to lasting effects of the ROP on the peripheral retina or to other aspects of these high-risk infants' medical condition. The results of our study allow us to eliminate several possible explanations.

**Table 1. Complications related to preterm birth**

<table>
<thead>
<tr>
<th>Condition</th>
<th>ROP group</th>
<th>No-ROP group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronchopulmonary dysplasia</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Hyaline membrane disease</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Perventricular leukomalacia</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Intraventricular hemorrhage</td>
<td>Grade III</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Grade II</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Grade I</td>
<td>0</td>
</tr>
<tr>
<td>Perinatal hypoxia/asphyxia</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Hyperbilirubinemia</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

First, the reduction in visual field size was not due to a decrease in visual acuity because the spheres used as stimuli were quite large (6° in diameter). In addition, as part of another study we measured each infant's visual acuity and found that there was no correlation between visual acuity and visual field size. Likewise, many infants who have ROP also develop strabismus, which can produce an increase in visual field size (exotropia) or a decrease in visual field size (esotropia). However, this cannot explain our results since none of the infants in either group had strabismus at any of the test ages.

Central nervous system (CNS) problems are common in this population, as well. Complications include intraventricular hemorrhage (IVH) and periventricular leukomalacia (PVL), which may involve the visual pathways. As shown in Table 1, the incidence of CNS complications was slightly greater in
Fig. 2. Mean visual field size, averaged across the 45°, 135°, 225° and 315° half-meridia for the ROP and no-ROP groups, tested at 4, 9, and 18-months corrected age. Bars indicate ± 1 SEM. Visual field size increases with age in both groups. However, the ROP group showed significantly smaller fields at 9 months than did the no-ROP group.

the ROP group. However, the two infants who had either PVL or PVL plus IVH were not the ones who showed field deficits. The incidence of other complications related to preterm birth was similar in the ROP and no-ROP groups, and thus also could not be responsible for the differences between groups.

The most plausible explanation for the visual field deficits seen in this study is that the peripheral retina is affected in some way by the presence of stage 3 ROP. Although we do not have enough data to offer a definitive confirmation of this hypothesis, critical aspects of our results are consistent with this proposition. First, the only infants who showed visual field deficits were those who had stage 3 ROP in the nasal retina in early infancy. Infants who had stage 3 ROP only in the temporal retina showed no visual field deficits, as would be expected, since our visual field testing was done binocularly, which would preclude detection of deficits in the temporal retina (nasal fields).

A second aspect of our data consistent with the hypothesis that the reduced field size in the ROP group was related to the ROP was that the deficit was seen at the 9-month test age, when visual fields are large enough to involve the far periphery of the retina, but not at 4 months, when measured visual field size is only about 50°, even in normal full-term infants.4 We have shown that kinetic perimetry can be used to measure binocular visual fields in infants with stage 3 ROP. Our results revealed a significant reduction in visual field development at 9 months in the ROP group and a tendency towards a delay at 18 months. Comparison of the location of the stage 3 ROP and the direction of the visual field deficit suggested that there was a relationship between the anatomic location of the stage 3 ROP in early infancy and visual field defects in late infancy. We cannot state if these defects will be lasting or if they just represent a delay in visual field development. Additional studies are being conducted on these children to provide an answer to this question.

Key words: retinopathy of prematurity, visual fields, infants

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