Resolution Visual Fields in Children Surgically Treated for Bilateral Congenital Cataract

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PURPOSE. To evaluate visual acuity (best corrected visual acuity) and peripheral sensitivity, measured by high-pass resolution (HRP) visual fields, in children surgically treated for congenital cataract.

METHODS. Acuity and peripheral sensitivity were recorded from 16 children, aged 10 to 15 years, either surgically treated for bilateral dense cataract before the age of 4.6 months (n = 10) or surgically treated for bilateral partial cataract at ages 4 to 139 months (n = 6). Data from 22 healthy children, mean age 11 years, served as control.

RESULTS. The children with cataract had significantly (P < 0.0001) lower decimal acuity in their better eye (median, 1.2; range, 0.1–1.3) than did the control subjects (median, 0.55; range, 1.0–1.6). Five children were visually impaired according to the World Health Organization’s definition (i.e., acuity in the better eye <0.3). The children with previous dense bilateral cataract showed significantly lower peripheral sensitivity than did the control subjects (P = 0.004). Significant correlations were observed between acuity and visual field parameters.

CONCLUSIONS. Dense cataract, even when surgically treated before the age of 4.6 months, causes persistent impairment of spatial vision, both in the fovea and the visual field. The effect on the visual field is less pronounced than that on visual acuity. This finding has to be taken into account when evaluating visual field results in, for example, the diagnosis of glaucoma, a frequent complication after cataract surgery in early infancy.

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Congenital cataract causes various degrees of visual form deprivation that may result in amblyopia. Psychophysical studies of form deprivation due to dense cataract have indicated that visual acuity and peripheral vision have a very long sensitive period for damage, from 10 days to 7 to 10 years of age.1

In children born with dense central cataract in both eyes, the development of acuity after birth is delayed compared with that in normal infants,2,3 until the occluding lens opacities are removed surgically (for review, see Maurer and Lewis4). However, despite early surgery, most children with dense bilateral cataracts have deficits in visual acuity during childhood.5,6 In a previous study of children in western Sweden with dense congenital cataract operated on before 36 weeks of age, an improvement in visual acuity up to 10 years of age was found.7 Information about the development of the spatial resolution in the visual field is sparser after early surgery for bilateral congenital cataracts.

It has been shown that peripheral vision normally develops rapidly during the first months of life, with a much slower or negligible increase after 6 months of age at different eccentricities.8,9 Previous studies of the impact on peripheral vision of children treated for cataract have shown constricted Goldmann visual fields.10 This decrease in sensitivity was largest in the temporal hemifield, not related to visual acuity and could not be explained by optical factors alone. Patching of the nondeprived eye in unilateral cases resulted in a less marked sensitivity decrease in the temporal field.10 Poor sensitivity in the nasal hemifield in static perimetry was observed in children treated for unilateral, or unilateral congenital cataract.11

Mioche and Pererin12 found decreased contrast sensitivity along the horizontal meridian, equal in both hemifields, out to 50° in subjects with amblyopia due to bilateral congenital cataract surgically treated between 4 months and 7 years of age. The peripheral deficit was worse in children with complete compared with those with incomplete cataract.

In the present study we used high-pass resolution perimetry to document the outcome of peripheral vision in children with severe early visual deprivation. The primary purpose was to characterize quantitatively the spatial resolution in the peripheral visual field from children with dense congenital cataract who underwent surgery during the first 5 months of life with respect to acuity and peripheral sensitivity. In addition, we evaluated the same data in children surgically treated for partial bilateral congenital cataract with more limited but more extended periods of early visual deprivation.

METHODS

Study Populations

Data from two groups of children with surgically treated bilateral dense congenital cataract were used in the study. One group consisted of children with bilateral dense cataract and the other with bilateral partial cataract. Dense cataract was defined as a condition in which the undilated pupil area is totally covered by the cataract, and no red reflex is obtained. Partial cataracts were defined as having a congenital origin and a severity that from infancy significantly interferes with vision, but it does not totally cover the pupillary area in ambient room lighting.

Inclusion criteria were clear media after treatments and visual field measurements performed at one or more occasions at the age of 10 to 15 years. Exclusion criteria were mental retardation, follow-up with other types of perimetry, or unreliable visual field results, according to criteria presented by the test used.

Table 1 shows clinical data from the examined cataract subjects. Twenty-three children born in the counties of Västra Götaland and Halland between 1980 and 1995 had a diagnosis of dense bilateral congenital cataract. Ten of these aphakic children aged 10 to 15 years, five boys and five girls with bilateral surgical treatment before the age of 4.6 months (median 11 days), were included in the study. All children were operated on with lensectomy and anterior vitrectomy, and the duration between the first and second treated eyes was on average 2 to 3 days. All children except two (cases 2 and 5) had strabismus, and eight had nystagmus. Two children (cases 4 and 8) had glaucoma in one eye; one was blind in that eye. Three subjects had...
been successfully treated for after-cataract with YAG laser capsulotomy. Vision in all subjects was corrected with contact lenses on the day of the surgery, except in two who wore glasses (cases 5 and 7).

A cohort of 28 children with bilateral partial cataract were surgically treated in the county of Västra Götaland. Between 1980 and 1995, data were collected from six children aged 10 to 15 years, two boys and four girls, surgically treated for bilateral partial cataract between the ages of 4 and 45 months. The median duration between the first and second treated eyes was 60 days (range, 10–870). Vision in all subjects was corrected with contact lenses on the day of the surgery, and one subject (patient 12), had an intraocular lens inserted from the age of 15 years; until then, she had used contact lenses. Four subjects were treated for after-cataract with good results. Two had exotropia, and two had nystagmus. One subject had ocular hypertension, without any visible optic disc damage diagnosed, in one eye at the age of 12 and topical treatment with antiglaucoma drugs since then.

Data regarding acuity and peripheral sensitivity results from 22 healthy children, born at term (mean age, 11 years; range, 10.3–11.2), 12 boys and 10 girls, from a previous study were used as reference values. The subjects in that study had been randomly selected from the birth registers of the Swedish National Board of Health and Social Welfare. They were all naive to visual field examinations. One normal child with unreliable visual field results was not included in the present study.

Written informed consent was obtained from all parents, after explanation of the nature and possible consequences of the study, before enrollment.

### Visual Acuity and Visual Field Examinations

Monocular acuity from all children was obtained at a 4-m distance using a Hedin decimal line letter chart. Acuity was defined according to clinically practice as the smallest line with at least 75% correctly read letters.

For quantitative evaluation of the central visual field, examinations were performed with a high-pass resolution perimeter (HRP; Ophthimus, ver. 3.0; HighTechVision, Göteborg, Sweden) extensively described elsewhere. In short, the method relies on spatially high-pass frequency–filtered, ringshaped targets presented with a space-average luminance equal to the background (20 cd/m²) and constant contrast. The stimuli sizes range from 0 to 14 dB, where 0 dB corresponds to a visual angle of 4.5 minutes of arc. Fifty locations are tested within the central 5° to 30° field at a viewing distance of 0.167 m. The task for the examined subject is practically the same as in all visual field tests—to keep fixation on a dynamic fixation mark and press a button when a ring-shaped target is perceived. Test duration is approximately 5 minutes per eye. The results are given in both global and local indices. The index used in the present study is the mean resolution threshold (MRT; i.e., the mean of all measured values at the 50 test locations expressed as dB). Decibel values were used for description and converted to MAR and logMAR for comparisons and correlations with acuity data, respectively.

The normal HRP visual field is characterized by an increase in threshold with eccentricity, with a mean difference between the outermost locations and the innermost locations of 2.4 dB. The learning effect is estimated to 0.2 to 0.5 dB between the first and second examination.

Examination reliability is automatically calculated by the HRP program. During the examinations, the subjects had vision correction according to refractive errors and the short testing distance (0.167 m). Subjects with contact lenses wore them during the examination.

The right eye was tested first in all subjects and in all examinations. For the subjects with cataract, data from examinations performed as close as possible to the age of 11 (the age of the control group) were chosen for comparison. All subjects with cataract except two had undergone HRP visual field examination at least once before these examinations, and all visual fields, included in the study, showed reliable results, according to the HRP program.

Data for the better eyes and worse eyes were analyzed separately, according to acuity at the time of the visual field examination. Since the controls had equal acuity in both eyes, the better eye according to the MRT was chosen for analysis. In all cases, this was the left, second-examined eye.

Comparisons were made between the cataract and the control groups regarding MRT from the total field, the hemifields, and from each quadrant. In addition, the MRT of the eight innermost locations at 5° eccentricity and the 16 outermost locations at 20° to 30° eccentricity were analyzed.

By transforming the decimal acuity and the MRT data to the relevant angular measure, we calculated the relative impairment in acuity and spatial resolution. This calculation was made by dividing the difference between the two cataract groups and the control group with the measured value in the control group.

For all normal distributed values the Student’s t-test and linear regression were used. For correlations between non-normally distributed data, the Mann-Whitney and the Spearman rank correlation tests

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**Table 1. Data from the Subjects with Cataract**

<table>
<thead>
<tr>
<th>Case</th>
<th>Age at Surgery and Optical Correction for BE (d)</th>
<th>Sequels</th>
<th>Complications</th>
<th>Acuity at 10–15 Years</th>
<th>HRP at 10–15 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>logMAR (Snellen Equivalent)</td>
<td>BE/WE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 DC</td>
<td>L/10</td>
<td>Nystagmus, strabismus</td>
<td>—</td>
<td>0.6/0.6 (20/80)/(20/80)</td>
<td>6.0/9.2</td>
</tr>
<tr>
<td>2 DC</td>
<td>L/53</td>
<td>—</td>
<td>After cataract*</td>
<td>0.0/0.3 (20/20)/(20/40)</td>
<td>3.8/7.1</td>
</tr>
<tr>
<td>3 DC</td>
<td>R/2</td>
<td>Nystagmus, strabismus</td>
<td>After cataract*</td>
<td>0.2/0.7 (20/30)/(20/100)</td>
<td>5.2/8.4</td>
</tr>
<tr>
<td>4 DC</td>
<td>R/5</td>
<td>Nystagmus, strabismus</td>
<td>Glaucoma</td>
<td>0.4/1.0 (20/50)/(20/200)</td>
<td>5.9/5.6</td>
</tr>
<tr>
<td>5 DC</td>
<td>R/11</td>
<td>—</td>
<td>After cataract*</td>
<td>0.3/0.7 (20/40)/(20/100)</td>
<td>4.6/4.7</td>
</tr>
<tr>
<td>6 DC</td>
<td>R/119</td>
<td>Nystagmus strabismus</td>
<td>—</td>
<td>0.1/0.2 (20/25)/(20/50)</td>
<td>4.4/5.0</td>
</tr>
<tr>
<td>7 DC</td>
<td>R/136</td>
<td>Nystagmus, strabismus</td>
<td>—</td>
<td>0.8/0.8 (20/120)</td>
<td>6.0/9.2</td>
</tr>
<tr>
<td>8 DC</td>
<td>R/100</td>
<td>Nystagmus, strabismus</td>
<td>—</td>
<td>0.6/2.0 (20/80)/(20/2000)</td>
<td>7.3/14</td>
</tr>
<tr>
<td>9 DC</td>
<td>L/51</td>
<td>Nystagmus, strabismus</td>
<td>—</td>
<td>0.5 (20/60)</td>
<td>5.4</td>
</tr>
<tr>
<td>10 DC</td>
<td>R/3</td>
<td>Strabismus</td>
<td>—</td>
<td>0.2/0.2 (20/30)/(20/20)</td>
<td>5.1/5.5</td>
</tr>
<tr>
<td>11 PC</td>
<td>L/271</td>
<td>—</td>
<td>After cataract*</td>
<td>1.0/1.0 (20/200)/(20/200)</td>
<td>5.6/6.5</td>
</tr>
<tr>
<td>12 PC</td>
<td>R/244</td>
<td>Strabismus</td>
<td>—</td>
<td>0.0/0.4 (20/20)/(20/50)</td>
<td>4.6/5.6</td>
</tr>
<tr>
<td>13 PC</td>
<td>L/189</td>
<td>Nystagmus, strabismus</td>
<td>Ocular hypertension</td>
<td>0.0/0.2 (20/40)/(20/2000)</td>
<td>5.2/7.2</td>
</tr>
<tr>
<td>14 PC</td>
<td>L/4245</td>
<td>Strabismus</td>
<td>After cataract*</td>
<td>0.9/1.0 (20/150)/(20/200)</td>
<td>5.2/7.2</td>
</tr>
<tr>
<td>15 PC</td>
<td>L/888</td>
<td>—</td>
<td>After cataract*</td>
<td>0.2/0.3 (20/30)/(20/40)</td>
<td>5.0/8.1</td>
</tr>
<tr>
<td>16 PC</td>
<td>L/1392</td>
<td>—</td>
<td>—</td>
<td>0.0/0.0 (20/20)/(20/20)</td>
<td>4.9/4.9</td>
</tr>
</tbody>
</table>

Acuity, best corrected visual acuity in logMAR; DC, dense cataract; PC, partial cataract; BE, better eye; R, right; L, left; sequences, effects of the disease; complications, side-effects of the surgery.

* Successfully treated.
RESULTS

Table 1 shows ages at the time of surgery and optical correction, acuity, and MRT from each subject with cataract. Table 2 shows median acuity and visual field results from the examined groups, from best and worst eye, respectively. Of the 51 subjects with cataract who were born in the counties of Västra Götaland and Halland between 1980 and 1995, 35 were excluded. Five had mental retardation and 30 were either not included at the time of examination according to the World Health Organization (WHO) criterion (decimal acuity, 20/60 in the better eye).

The study was approved by the local ethics committee and performed according to the Helsinki Declaration.

Visual Acuity

LogMAR acuity in the better eyes ranged from −0.20 to 0.0 in the control subjects, from 0.0 to 0.80 in the dense-cataract group; and from −0.11 to 0.89 in the partial-cataract group. Corresponding values for the worse eye was −0.20 to 0.0, 0.19 to 2.0, and 0.0 to 1.0, respectively. The cataract groups had significantly (*P < 0.0001) lower mean acuity in the better eye than did the control subjects (Table 2). In 14 of the 16 subjects with cataract, both eyes were examined. Six of them showed a significant difference (≥0.2 logMAR15) in acuity between the eyes. One subject (patient 8) had a difference of 1.4 logMAR, and the other five ranged from 0.3 to 0.7 logMAR.

Five subjects with cataract (three in the dense cataract and two in the partial-cataract group) were judged as visually impaired at the time of examination according to the World Health Organization (WHO) criterion (decimal acuity, <0.3; 20/60 in the better eye).

Resolution Visual Fields

All subjects with cataract and 20 out of 22 control subjects showed reliable visual field results. Two control subjects showed borderline reliability. Significant correlations were found between acuity and the MRT in the entire visual field (r² = 0.48; linear regression, P = 0.003; MRT = 1.099 + 0.19 × acuity), the innermost locations (r² = 0.48, P = 0.0032; MRTinner = 1.007 + 0.278 × acuity), and the outermost locations (r² = 0.56, P = 0.0007; MRTouter = 1.191 + 0.196 × acuity) in the better eye of the subjects with cataract.

The two subjects, examined wearing spectacles both had normal threshold slopes (expressed as dispersion index in the HRP program), indicating no influence on the peripheral sensitivity of the glass correction.

No significant differences were found between quadrants or hemifields between the groups. No correlation was found between age at surgery on the better eye and acuity or any of the peripheral sensitivity parameters in the dense- or partial-cataract group.

Ten subjects with cataract (eight in the dense-cataract and two in the partial-cataract group) had manifest nystagmus. Decimal acuity in the better eye ranged from 0.13 to 1.0 and MRT ranged from 4.4 to 7.3 dB. Corresponding values for the six subjects without nystagmus were 0.1 to 1.3 dB and 3.5 to 5.6 dB, respectively. The difference in MRT between subjects with and without nystagmus was statistically significant (Mann-Whitney test, P = 0.04) but not the difference in acuity (P = 0.07).

The MRT difference between better and worse eyes in the control group (i.e., the second and first examined eye in this group) was −0.65 ± 0.58 dB, indicating a learning effect. This was in line with previous reported data.16–18 The MRT difference in the cataract group was larger, −1.74 ± 1.96 dB. However, none of these differences was statistically significant.
DISCUSSION

Our finding of decreased sensitivity in the centermost locations of the visual field in the dense-cataract group is in line with the reports of Mioche and Perenin and Ellenberg et al. of decreased contrast sensitivity within the central 5° field. However, Mioche and Perenin also noted impaired contrast sensitivity in cases with treated bilateral partial cataracts, whereas our partial-cataract group had almost unaffected visual fields. The explanation of this discrepancy may be that the amblyopia in the subjects with partial cataracts in the Mioche and Perenin study was more severe than that in our partial-cataract group—actually even worse than in our dense-cataract group. No difference was found between hemifields in bilateral deprivation in agreement with the study of Bowering et al.

In a previous multicenter study performed by Wall et al. of 640 normal subjects, the mean MRT was 4.17 ± 0.96 dB for ages between 10 and 89 years and 3.72 ± 0.78 dB (n = 34) in the age-group 10 to 19 years, and the mean difference between the outermost locations and the innermost locations was 2.4 dB. The findings in the present study regarding MRT and threshold increase with eccentricity in the control group were very similar (4.35 and 2.3 dB, respectively).

Peripheral sensitivity in children with bilateral severe deprivation amblyopia after treatment of cataract in early infancy has been shown to be impaired. In agreement with the findings in the present study, HRP has been used for function measurements in amblyopia. In a study of adults with amblyopia due to anisometropia and/or strabismus and with a decimal acuity in the ambyopic eye from finger-counting to 0.5 (20/40), no abnormalities were detected within the 5° to 30° visual field from the ambyopic eye. Thus, the findings in this study indicate that amblyopia due to congenital cataract induces defective form vision in a wider retinal area, compared with anisometropia and strabismus.

Visual field testing is important for diagnosing late-onset aphakic glaucoma. Our study demonstrates that HRP is a suitable perimetric test for children, in agreement with Maraffa et al. The current description of the impact on the peripheral sensitivity of bilateral visual deprivation, with or without nystagmus, may be useful in the diagnosis of glaucomatous field loss.

Correlation between Acuity and Peripheral Sensitivity MRT

The regression analysis showed significant correlations between acuity on the one hand and MRT, inner- or outermost test locations in the visual field, on the other. Thus, visual deprivation in infancy appears to influence spatial vision, not only in the fovea but also in the 30° visual field.

CONCLUSION

Dense cataract, even when surgically treated before the age of 4.6 months, causes persistent impairment of spatial vision, both in the fovea and the visual field. The effect on the visual field is less pronounced than on visual acuity. Partial cataract without severe amblyopia had, in the present study, practically no effect on the visual field. However, due to the small number of subjects tested, this small impact on peripheral vision precludes firm conclusions. Knowledge about the impact of visual deprivation on the visual field of the aphakic eye may be useful in the diagnosis of glaucoma, a frequent complication after cataract surgery in early infancy.

References