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Monocular oral reading after treatment of dense congenital unilateral cataract

Eileen E. Birch, PhD^{a,b}, Christina Cheng, BS^a, V Christina, BA^a, and David R. Stager Jr, MD^{b,c}

^aPediatric Eye Research Laboratory, Retina Foundation of the Southwest, Dallas

^bDepartment of Ophthalmology, University of Texas Southwestern Medical Center, Dallas

^cPediatric Ophthalmology, P.A. & The Center for Adult Strabismus, Dallas

Abstract

Background—Good long-term visual acuity outcomes for children with dense congenital unilateral cataracts have been reported following early surgery and good compliance with postoperative amblyopia therapy. However, treated eyes rarely achieve normal visual acuity and there has been no formal evaluation of the utility of the treated eye for reading.

Methods—Eighteen children previously treated for dense congenital unilateral cataract were tested monocularly with the Gray Oral Reading Test, 4th edition (GORT-4) at 7 to 13 years of age using two passages for each eye, one at grade level and one at +1 above grade level. In addition, right eyes of 55 normal children age 7 to 13 served as a control group. The GORT-4 assesses reading rate, accuracy, fluency, and comprehension.

Results—Visual acuity of treated eyes ranged from 0.1 to 2.0 logMAR and of fellow eyes from −0.1 to 0.2 logMAR. Treated eyes scored significantly lower than fellow and normal control eyes on all scales at grade level and at +1 above grade level. Monocular reading rate, accuracy, fluency, and comprehension were correlated with visual acuity of treated eyes ($r_s = -0.575$ to -0.875 , $p < 0.005$). Treated eyes with 0.1–0.3 logMAR visual acuity did not differ from fellow or normal control eyes in rate, accuracy, fluency, or comprehension when reading at grade level or at +1 above grade level. Fellow eyes did not differ from normal controls on any reading scale.

Conclusions—Excellent visual acuity outcomes following treatment of dense congenital unilateral cataracts are associated with normal reading ability of the treated eye in school-age children.

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Reprint requests: Eileen E Birch, PhD, Retina Foundation of the Southwest, 9900 North Central Expressway, Suite 400, Dallas, TX 75231, (ebirch@retinafoundation.org)..

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Introduction

Good long-term visual acuity outcomes have been reported following surgery for dense congenital unilateral cataracts by 6 weeks of age in tandem with prolonged optical and occlusion therapy.¹⁻⁵ However, treated eyes rarely achieve normal visual acuity.¹⁻⁵ There has been no formal evaluation of the utility of the treated eye for reading in the event of injury to the sound eye.

Reading is a critical measure of the potential utility of the affected eye since it is the foundation for academic success and there is a clear link between academic success in childhood and long-term social and economic outcomes.⁶ Oral reading is a particularly demanding task because it requires the decoding of graphemes into phonemes and the assembly of phonemes into words.⁷ Visual impairment may make decoding of graphemes more difficult, resulting in slow and/or inaccurate oral reading. In addition, if a visually impaired child directs more attention to decoding graphemes, less attention may be directed toward comprehension. We evaluated the oral reading ability of treated eyes with a standardized assessment of reading fluency and comprehension.

Methods

Participants

Participants included 18 children ages 7 to 13 years who had been diagnosed with a unilateral dense congenital cataract during the first 2 weeks of life (Table 1). Participants with cataracts were referred to the study by 8 Dallas–Fort Worth area pediatric ophthalmologists. All were fitted with an aphakic contact lens after cataract extraction at 1 to 19 weeks of age; 8 had an intraocular lens implanted as a secondary procedure at age 1.5 to 7 years. All had bifocal or multifocal spectacle correction for reading at the time of the study. These children were a convenience sample of children drawn from a larger group who are enrolled in an ongoing prospective longitudinal study of visual maturation following treatment for congenital cataract;^{2,3,8-11} they were contacted and scheduled for visual acuity and reading tests as a part of a summer internship project for a college student. Excluded from participation were children with associated retinal anomalies, systemic disease, or neurological disorders. Also excluded were children who were not native speakers of English and those who had been diagnosed with dyslexia or speech delay.

In addition, 55 children ages 7 to 13 with healthy eyes served as controls. Informed consent was obtained from one or both parents before the patient's participation.

This research protocol observed the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board of the University of Texas Southwestern Medical Center. All visual acuity and reading tests were administered by the Retina Foundation of the Southwest, which is a HIPAA-exempt institution.

Visual Acuity

Monocular visual acuity was measured using the E-ETDRS protocol on the EVA system.^{12,13} For some analyses, visual acuity of affected eyes was grouped as “Excellent” (0.10–0.30 logMAR; 20/25–20/40), “Moderate” (0.40–0.60 logMAR; 20/50–20/80), or “Poor” (0.7–2.0 logMAR; 20/100–20/2000).

Reading

The Gray Oral Reading Test 4 (GORT-4) is a widely used and validated test of oral reading for school-age children. It yields four outcome measures: reading rate, reading accuracy,

reading fluency, and comprehension. The GORT-4's grade level-appropriate print size decreases with grade level. Passage content, sentence structure, and overall difficulty are also grade-level appropriate. Two parallel versions (A & B) are available at each grade level with similar difficulty. Stories were presented in a binder placed on a desktop with the child seated at the desk with normal room lighting; this setting was chosen to mimic typical classroom reading conditions. Testing was monocular; the child wore an adhesive patch and their spectacle correction. An abbreviated test protocol was used. Each eye was tested with two stories, one at grade level and one at +1 above grade level. For example, if the child was tested during the summer after competing third grade, they were tested with Story 3 (at grade level) and Story 4 (+1 grade level). The treated eye was tested first with version A, and then the fellow eye was tested with version B. Testing for each story consisted of timed oral reading, noting errors in the spoken words, and five multiple-choice questions to evaluate comprehension.

Statistical Analysis

Reading rate was measured as the number of seconds required to complete oral reading of the passage. Accuracy was measured as the number of errors in the spoken words. Reading rate and accuracy were converted to scaled scores using the scoring key published by the manufacturer for each story; each of the scores could range from 0 to 5. Fluency was the sum of the rate and accuracy scaled scores (0 to 10). Comprehension was scored as the number of questions answered correctly (0 to 5). Median scaled reading rate, accuracy, fluency, and comprehension scores were compared among affected eyes, fellow eyes, and normal control eyes using Kruskal-Wallis ANOVA with multiple post hoc pairwise comparisons. Correlations between visual acuity and reading rate, accuracy, fluency, and comprehension scores were evaluated using Spearman rank correlation. Visual acuity (logMAR) comparisons between groups were conducted by *t*-test.

Results

Visual acuity of treated eyes ranged from 0.10 to 2.0 logMAR; 6 eyes had excellent visual acuity (0.10–0.30 logMAR), 7 had moderate visual acuity (0.40–0.60 logMAR), and 5 eyes had poor visual acuity (≥ 0.70 logMAR). Visual acuity of fellow eyes and of control eyes ranged from -0.10 to 0.30 logMAR (20/15–20/40). Visual acuity of treated eyes was significantly poorer than visual acuity of fellow eyes (0.73 ± 0.65 logMAR vs 0.05 ± 0.29 logMAR; $t = 4.05$, $p = 0.0003$) and of control eyes (0.73 ± 0.65 logMAR vs 0.02 ± 0.16 logMAR; $t = 7.53$, $p < 0.0001$). There was no significant difference between the visual acuity of fellow eyes and visual acuity of control eyes (0.05 ± 0.29 logMAR vs 0.02 ± 0.16 logMAR; $t = 0.56$, $p = 0.56$).

As shown in Figure 1, compared with normal controls and fellow eyes, treated eyes had a wide range of scaled scores for reading rate, accuracy, fluency, and comprehension, ranging from normal to well below normal. There was a significant main effect of eye type (affected, fellow, normal control) for rate, accuracy, fluency, and comprehension when reading at grade level ($H_{2,91} > 7.7$ and $p \leq 0.02$ for all comparisons) and at +1 above grade level ($H_{2,91} > 10.6$ and $p \leq 0.005$ for all comparisons). Median scaled scores for affected eyes were lower than for fellow and normal control eyes on all four scales at grade level and at +1 above grade level ($p \leq 0.03$ for all pairwise comparisons). There were no significant differences between fellow and normal control eyes.

Reading rate, accuracy, fluency, and comprehension when reading with affected eyes were moderately correlated with visual acuity outcome at grade level and at +1 above grade level (r_s ranged from -0.575 to -0.875 ; $p < 0.02$ for all correlations). Correlations between monocular reading scores and visual acuity were not significant for fellow eyes at grade

level and at +1 above grade level (r_s ranged from -0.258 to 0.192 ; $p > 0.3$ for all correlations). Similarly, correlations between monocular reading scores and visual acuity were not significant for normal control eyes at grade level and at +1 above grade level (r_s ranged from -0.206 to 0.132 ; $p > 0.1$ for all correlations). Finally, monocular reading scores for affected and fellow eyes were not significantly correlated at grade level or at +1 above grade level (r_s ranged from 0.268 to 0.447 ; $p > 0.07$ for all correlations).

Treated eyes with excellent visual acuity (0.1 – 0.3 logMAR; Figure 2) had a narrow range of scaled scores for reading rate, accuracy, fluency, and comprehension, similar to normal control eyes. There was no significant main effect of eye type (affected, fellow, normal control) for rate, accuracy, fluency, or comprehension when reading at grade level ($H_{2,67} < 1.2$ and $p > 0.5$ for all comparisons) and at +1 above grade level ($H_{2,67} < 4.9$ and $p > 0.09$ for all comparisons). Median scaled scores for affected eyes were similar to fellow and normal control eyes on all four scales at grade level and at +1 above grade level.

Conclusions

Overall, reading with an eye treated for dense congenital unilateral cataract results in slower reading rate, poorer accuracy, and poorer comprehension than was found for the fellow eye or for normal control eyes. Slower reading rate and reduced accuracy may result because the visual acuity of the affected eye is closer to the critical reading print size¹⁴ than the visual acuity of the fellow eye or of normal control eyes are. The GORT-4 reading passages at grade level and at +1 above grade level used in this study had font sizes of 10 to 14 point, approximately corresponding to visual acuities of 1.1 to 0.75 logMAR. Reading speed is known to decrease at print sizes within 0.2–0.3 logMAR of visual acuity¹⁰. Our cohort included children whose visual acuity for the aphakic eye was near to or poorer than the print size of the passages they were asked to read. The lower comprehension score when reading with an eye treated for unilateral cataract likely may result from the child spending more time visually decoding graphemes⁷ and, therefore, being less attentive to meaning. The absence of a significant correlation between reading scores for affected and fellow eyes suggests that visual acuity of the treated eye and overall reading skills are not associated. That is, the visual acuity outcome of the treated eye is associated only with monocular reading scores for the affected eye.

Children who achieved excellent visual acuity outcomes after treatment for a dense congenital unilateral cataract also achieved normal reading rate, accuracy, fluency, and comprehension when reading with the treated eye. This result supports the expenditure of effort and expense to maximize the function of the aphakic/pseudophakic eye. Note that the cohort that participated in this study was a convenience sample of children and, as such, the proportions of children with excellent, moderate, and poor visual acuity outcomes do not represent the prevalence of these outcomes in the larger population of children treated for dense congenital unilateral cataract in our geographical area.

One limitation of our study is that we did not administer the entire GORT-4 test to each child since it was too time consuming to incorporate into our research protocol. Instead, each child was tested with the grade-level appropriate passages and the passages that corresponded to one level above grade level. Therefore, it is possible that the scores we obtained with the abbreviated method are not comparable to those in the large GORT-4 normative database. However, this limitation was ameliorated by our having a normal control group that was tested using the same abbreviated method.

There have been no prior studies of monocular reading ability for children treated for deprivation amblyopia following extraction of congenital unilateral cataract. Two recent

studies assessed monocular reading of children with treated amblyopia. One¹⁵ reported poorer reading speed in treated amblyopic eyes than fellow eyes but did not assess accuracy or comprehension; the other¹⁶ reported slightly worse rate, accuracy, and fluency scores in treated amblyopic eyes than in fellow eyes but no significant difference in comprehension. This latter study's ability to assess the impact of visual acuity deficit on comprehension was limited, however, because none of the amblyopic eyes had visual acuity poorer than 20/63 and few had visual acuity poorer than 20/40.

In summary, monocular oral reading ability and comprehension with eyes previously treated for dense congenital unilateral cataract, when measured with an abbreviated version of the GORT-4, were worse compared with fellow eyes or normal control eyes.

Monocular visual acuity of treated eyes was correlated with the monocular reading rate, accuracy, fluency, and comprehension. The affected eyes of children who achieved excellent visual acuity following early surgery and aggressive postoperative management of optical correction and amblyopia treatment also achieved monocular oral reading ability and comprehension that did not differ significantly from fellow eyes or age-matched normal control eyes.

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FIG 1. Scaled monocular oral reading scores from 18 children treated for dense congenital unilateral cataracts (affected and fellow eyes) and 55 normal control children (right eyes). Each box shows the 25th - 75th interquartile range (IQR). The horizontal line shows the median. The whiskers show ± 1.5 IQR. Isolated data points indicate outliers. Each eye was tested with two stories, one at grade level and one at +1 above grade level.

FIG 2.

Scaled monocular oral reading scores from 6 children treated for dense congenital unilateral cataracts who had excellent visual acuity outcomes (affected and fellow eyes; 0.10-0.30 logMAR) and 55 normal control children (right eyes). Each box shows the 25th-75th interquartile range (IQR). The horizontal line shows the median. The whiskers show ± 1.5 IQR. Isolated data points indicate outliers. Each eye was tested with two stories, one at grade level and one at +1 above grade level.

Table 1
Characteristics of study participants

	n	Age (years)	Highest grade completed	Age at Surgery (weeks)	Visual acuity of affected eye* (logMAR)	Visual acuity of fellow eye* (logMAR)
Children treated for dense congenital unilateral cataract	18	7-13	1st-7th	3-19	0.1-2.0 (20/25-20/2000)	-0.1-0.3 (20/16-20/40)
Excellent [‡]	6	7-13	1st-7th	3-6	0.1-0.3 (20/25-20/40)	-0.1-0.3 (20/16-20/40)
Moderate [‡]	7	7-13	1st-7th	4-19	0.4-0.6 (20/50-20/80)	-0.1-0.3 (20/16-20/40)
Poor [‡]	5	7-13	1st-7th	1-13	0.7-2.0 (20/70-20/2000)	-0.1-0.3 (20/16-20/40)
Normal control	55	7-13	1st-7th	-----	0.1-0.3 (20/16-20/40)	-0.1-0.3 (20/16-20/40)

* For normal controls, right eye visual acuity is presented in the affected eye column and left eye visual acuity is presented in the fellow eye column

[‡] Visual acuity of affected eyes was grouped as “Excellent” (0.10-0.30 logMAR; 20/25-20/40), “Moderate” (0.40-0.60 logMAR; 20/50-20/80), or “Poor” (0.7-2.0 logMAR; 20/100-20/2000).