Preverbal Photoscreening for Amblyogenic Factors and Outcomes in Amblyopia Treatment

Early Objective Screening and Visual Acuities

Valerie G. Kirk; Michelle M. Clausen, BA; M. Diane Armitage, CO; Robert W. Arnold, MD

Background: Previous studies have suggested that infant photoscreening yields better results than visual acuity screening in preschool-aged children. With conventional vision screening, the patient must be able to provide monocular visual acuity cooperation, whereas objective screening for amblyogenic factors can be done at much younger ages.

Methods: From February 1996 through February 2006, Alaska Blind Child Discovery photoscreened 21 367 rural and urban Alaskan children through grade 2, with an 82% positive predictive value (ie, true number of those referred); 6.9% were referred for a complete eye examination and treatment. All “referred” interpreted images for children younger than 48 months who were then followed up and treated for more than 2 years were reviewed to determine whether treatment was successful.

Results: Of 411 “positive” screening photos from children younger than 4 years, 94 patients had more than 2 years follow-up. The 36 children photoscreened before age 2 years had a mean treated visual acuity of 0.17 logarithm of the minimum angle of resolution (logMAR), which was significantly better than that of 58 children screened between ages 25 and 48 months (mean, 0.26 logMAR). Despite similar levels of amblyogenic risk factors, the proportion of children failing to reach a visual acuity of 20/40 was significantly less among those screened before age 2 years (5%) than in those screened from ages older than 2.0 years and younger than 4.0 years (17%).

Conclusion: Very early photoscreening yields better visual outcomes in amblyopia treatment compared with later photoscreening in preschool-aged children.

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AMBLYOPIA IS A PUBLIC health disease that meets World Health Organization guidelines for screening. The American Academy of Pediatrics (AAP), working with ophthalmologists, endorses a series of age-appropriate screening measures to promote timely treatment. Conventional screening of visual acuity is accompanied by objective measures to detect the main risk factors for amblyopia: cataract, strabismus, and high refractive error. Photoscreening and remote autorefraction, newer technologies that allow lay detection of refractive error and ocular alignment, have shown promise but are not yet recommended by the AAP. The recent National Institutes of Health–supported Vision In Preschoolers Study ranked various sensory and objective screening modalities used in Head Start preschool programs and found that the most sensitive were internally calibrated remote autorefraction and patched logarithms of the minimum angle of resolution (logMAR) visual acuity testing, with externally interpreted photoscreening lagging behind. The validity of photoscreening varies by technology, screener experience, and the method of interpretation. Proponents of widespread community photoscreening have demonstrated high positive predictive value for this technique. Photoscreening outperforms conventional visual acuity testing in pediatrician’s offices and in early elementary school.

Recent studies have suggested the value of very early photoscreening. Donahue reviewed records from children with anisometropia detected by the Tennessee statewide screening program and found that the proportion of children with amblyopia and the severity of amblyopia increased with each preschool year from 1 to 5. Atkinson et al used videorefraction to detect high hyperopia in infants aged 8 to 9 months. Improved visual acuity and school performance were associated with early treatment. We, therefore, reviewed our long-term experience with our statewide...
program, Alaska Blind Child Discovery (ABCD), to determine whether early photoscreening influenced visual acuity outcomes.

The ABCD is a cooperative, charitable research effort to offer vision screening to urban and rural Alaskan children. The program has been approved by the Providence Hospital institutional review board since February 1996.13 The primary objective screening method has been lay community photoscreening (PhotoScreener; The PhotoScreener, Inc [formerly MTI], Lancaster, Pennsylvania), with physicians interpreting the data using the delta-center crescent method.14 Since 2001, the Polaroid film (Polaroid Corporation, Waltham, Massachusetts) used with the PhotoScreener has become more difficult to find, so digital flash cameras, remote autorefraction, and computer-interpreted infrared autorefraction have been calibrated to partly supplant the original technology. For this study, however, only children screened with the PhotoScreener were included.

A database of all ABCD statewide screenings has been maintained, and efforts have been made to collect follow-up data on confirmatory visual examination outcomes. Of all referred children screened before age 48 months who had confirmatory examinations, we sought long-term (at least 2 years) treatment outcomes for children now older than 6 years; 95% of these came from within our own practice. We also included 4 examination reports that were obtained with parental consent from local ophthalmologists and optometrists. All patients capable of undergoing monocular logMAR visual acuity screening (ie, patched, surround HOTV letters) are included in this report. The cycloplegic refraction, dates of last evaluation, visual acuities, and types of amblyopia treatment were included in the analysis. Patients were divided into categories based on American Association for Pediatric Ophthalmology and Strabismus (AAPOS) gold standard examination amblyopic risk factor criteria.15 Nonparametric analysis of logMAR visual acuity and $\chi^2$ analysis of the proportion failing to achieve 20/40 visual acuity after treatment was conducted using JMP statistical analysis software, version 5.0.1a (SAS Institute, Cary, North Carolina).

RESULTS

From February 1, 1996, through February 28, 2006, 21,367 community lay screenings were performed with a referral rate of 6.9% and an estimated AAPOS-compliant positive predictive value of 82%. Of the children screened, 10,620 were younger than 48 months when screened, 997 were aged 0 to 12 months, 1857 were aged 13 to 24 months, 2506 were aged 25 to 36 months, and 5280 were aged 37 to 48 months. Of the children referred before age 48 months, 411 are currently older than 6 years. Consistent follow-up examination data were available for 58 preschool-aged children (age at screening, 25-48 months) and 36 infants and toddlers (age at screening, 1-24 months) for a total of 94. The current mean (SD) age of these children was 10.2 (2) years (range, 6-15 years) and the duration of follow-up after screening ranged from 2 to 10 years (mean [SD], 5.1 [2.0] years).

Figure 1 shows treated logMAR visual acuities of children photoscreened as infants and toddlers compared with visual acuities of children screened at preschool age. Earlier screening resulted in better visual acuities (mean, 0.17 logMAR vs 0.26 logMAR; Wilcoxon rank sum $\chi^2 = 4.9$; $P = .03$). The proportion of children with posttreatment visual acuities worse than 20/40 was less for children photoscreened from ages 0 to 24 months ($\chi^2 = 4.4$, $P = .04$). Assuming equal difference between variances and using a $t$ test, there was no difference between younger and older children on the basis of degree of spherical equivalent hyperopia ($P = .11$), astigmatism ($P = .17$), and spherical equivalent anisometropia ($P = .48$). Figure 3 compares amblyopic posttreatment
visual acuity for infants and toddlers vs preschool-aged children by type of amblyopia. The follow-up rate and confirmatory examination outcomes across different screening ages were remarkably similar, which suggests an age-independent positive predictive value for photoscreening (Figure 4).

**COMMENT**

Infants and toddlers younger than 2 years who had amblyopia detected by photoscreening had treatment successes averaging about 1 logMAR line better than children who had amblyopia detected between ages 2 and 4 years. One extra line of visual acuity is substantial. The older group resembles the youngest children in the Pediatric Eye Disease Investigator Group Amblyopia Treatment Studies, which require a patient to reliably give a patched visual acuity for enrollment. So far, the Amblyopia Treatment Studies have treatment improvements of 3 to 4 lines of visual acuity but yield an imperfect, residual mean treatment amblyopic visual acuity of about 20/32.16

There are considerable weaknesses and limitations to our study. In particular, it was performed retrospectively and due, in part, to the vast expanse of Alaska, follow-up was incomplete. In addition, this review of visual acuity outcomes is derived from a prospective screening protocol rather than a prospective outcome/compliance study. Based on the PhotoScreening images, we do not suspect a different severity of amblyogenic factors in individuals with whom we had no follow-up. However, we are not sure whether differential compliance affects amblyopia outcomes. In addition, we do not know whether there is an age-dependent propensity toward more severe amblyopia for similar levels of amblyogenic refractive risk factors that might favor younger children. On the contrary, if a portion of the preschool-aged children with high hyperopia developed manifest esotropia that would prompt parents to seek eye examinations before rescheduling photoscreening, then these children might have been preferentially selected out of the community screening, which would suggest a trend toward less strabismus and better visual acuities in the older group. In fact, Donahue11 would suggest that the children referred earlier had less amblyopia, or had not yet developed amblyopia, at the time of referral.

One strength of this study is that the vast majority (>95%) of examinations and treatment plans were performed by the same pediatric ophthalmologist (R.W.A.) and orthoptist (M.D.A.). Whether earlier objective screening is better than later ramped-up amblyopia treatment in terms of compliance, residual visual acuity, or cost remains to be demonstrated by a long-term, community-screened randomized study. Our study combined with the results from Donahue11 and Atkinson et al12 argues for earlier objective screening.

If early objective screening can efficiently detect amblyopia so that treatment is effective, then the primary disadvantage is direct monetary cost and societal inconvenience estimated in cost. The cost to apply various screening paradigms with follow-up and treatment has been estimated by Arnold et al,17 and the AAP guidelines mention a cost of $516 per American child. Adding photoscreening at age 18 months increases the cost to $565. Compared to current AAP guidelines,1 adding photoscreening would increase the burden on overall American health care from $2.2 billion to $2.4 billion dollars per year, whereas adding mandated visual examinations upon enrollment in kindergarten could cost $3.3 billion. InfantSEE, a public
health program sponsored by the American Optometric Association, has estimated that scheduled visual examinations would cost about $4.8 billion per year. The annual economic value added in America for amblyopia care is estimated to be $27.9 billion.18

Visual acuity screening can work well in preschool-aged children when performed by trained experts. However, objective screening can outperform lay visual acuity testing in kindergarten- and preschool-aged children as well as in toddlers and infants. We recommend including valid objective screening in new AAP guidelines and determining a reasonable relative value unit for the Current Procedural Terminology code 99174 to cover it (Healthcare Common Procedure Coding System) and making screening available to toddlers and school-aged children in the United States.

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Correspondence: Robert W. Arnold, MD, Division of Pediatric Ophthalmology and Strabismus, Ophthalmic Associates, 542 W Second Ave, Anchorage, AK 99501-2242 (www.abcd-vision.org).

Author Contributions: Ms Clausen had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Financial Disclosure: The ABCD has received distributed vision screen technology from several vendors: The Photorecener, Inc; Welch Allyn, Skaneateles Falls, New York; Japan Victor Company, Tokyo; Gateway Computer, Irvine, California; Precision Vision, LaSalle, Illinois; Ad Tape and Label, Menominee Falls, Wisconsin; I-Screen, Memphis, Tennessee; EyeDx, San Diego, California; and PlusOptix, Nuremberg, Germany. No author has received direct payment from these vendors.

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REFERENCES


