

Detection of Red Reflex Asymmetry by Pediatric Residents Using the Brückner Reflex Versus the MTI Photoscreener

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ABSTRACT. *Objective.* To compare the ability of pediatric residents to differentiate an asymmetric from a symmetric red reflex in patients with anisometropia and microstrabismus using the Brückner reflex and the Medical Technology Innovations (MTI) photoscreener.

Methods. A prospective, masked, case-control study was performed. Twelve pediatric residents evaluated 10 study patients and 6 control subjects in a masked manner in 2 separate sessions, using the Brückner reflex or the MTI photoscreener, evaluating for asymmetric (abnormal) or symmetric (normal) red reflexes between the 2 eyes. Each study patient had asymmetric red reflexes and the amblyogenic risk factor of anisometropia or microstrabismus. Each control subject had symmetric red reflexes.

Results. The pediatric residents had a mean correct score of 82% (69%–100%) using the MTI photoscreener versus a mean correct score of 65% (44%–81%) using the Brückner reflex (McNemar test: $\alpha < 0.01$). The sensitivity of the MTI photoscreener evaluation was 89% in comparison to 61% for the Brückner reflex. The specificities for the MTI photoscreener versus the Brückner reflex were similar at 69% and 71%, respectively.

Conclusions. Pediatric residents were better at detecting asymmetric red reflexes in patients with anisometropia and microstrabismus when evaluating MTI photoscreener photographs than when evaluating the red reflexes by the Brückner reflex. The MTI photoscreener may be a more sensitive method than the Brückner reflex to screen for the common amblyogenic risk factors of anisometropia and microstrabismus by easier detection of red reflex asymmetry. *Pediatrics* 2001;108(4). URL: <http://www.pediatrics.org/cgi/content/full/108/4/e74>; *amblyopia, red reflex, photoscreener, Brückner, anisometropia, microstrabismus.*

ABBREVIATION. MTI, Medical Technology Innovations (photoscreener).

Amblyopia is estimated to affect approximately 2% to 5% of the US population¹⁻³ and is a significant preventable cause of vision loss in children and adults. When amblyopia or its

risk factors are detected early, amblyopia can be more readily treated or even prevented.⁴ Amblyogenic risk factors include anisometropia (significant difference in refractive error between the 2 eyes), strabismus, media opacity, and ptosis. A significant limiting factor of most amblyopia screening programs, however, is the reliance on the subjective responses of the children being tested.⁵ This limits screening to verbal children only, often leading to delayed diagnosis.

Two readily available screening tools that can be used with preverbal and nonverbal children by non-ophthalmologists include the Brückner reflex and photoscreening. The Brückner reflex is the first part of the Brückner test, first described in the United States by Tongue and Cibis.⁶ It involves utilization of a direct ophthalmoscope in an undilated patient to compare the pupillary red reflexes for asymmetry of color and brightness.⁶⁻⁸ Asymmetry of the pupillary red reflexes between the 2 eyes is strongly predictive of the amblyogenic risk factors of anisometropia, strabismus, or media opacity.^{6,7}

Photoscreening is a relatively new technique used to screen for amblyogenic risk factors. Photoscreening involves photographic imaging of the pupillary red reflexes of a patient and evaluation of the photographs by a trained reviewer. Asymmetry of the photographed red reflexes in the Medical Technology Innovations (MTI; Riviera Beach, FL) photoscreener photograph may indicate anisometropia, strabismus (including microstrabismus), or other amblyogenic risk factors. The photoscreener from MTI is the most widely studied in the literature and is available commercially. One major advantage of a photoscreener test over the Brückner reflex is that a photographic image is analyzed rather than the live, moving child. This allows the interpreter an unlimited amount of time for interpretation, and patient cooperation during the analysis is not necessary.

Photoscreeners have been tested in a variety of situations, typically using ophthalmologists, ophthalmic personnel, and/or ophthalmic researchers as the screeners. Wide variation in sensitivity and specificity between studies has been demonstrated, possibly because of heterogeneous interpreter background, heterogeneous or undefined patients, or variable quality of the photographs.⁹⁻¹⁵ Testing results solely from nonophthalmic personnel have received little attention. Because nonophthalmic personnel, such as pediatricians, usually perform vision screening and, therefore, typically have the first

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chance to detect potentially vision-threatening risk factors, it is important to evaluate amblyopia screening techniques specifically within this group.

When designing a vision-screening program, it is important to make test interpretation straightforward and efficient; otherwise, the interest and participation of potential vision screeners could be lost. Anisometropia and strabismus are the most common causes of amblyopia, and they both cause red reflex asymmetry. The purpose of this study was to compare the ability of pediatric residents to detect the amblyogenic risk factors of anisometropia and microstrabismus (strabismic deviation of <10 prism diopters), by distinguishing asymmetric red reflexes (abnormal screening result) from symmetric red reflexes (normal screening result), using the Brückner reflex and the MTI photoscreener.

METHODS

A prospective, masked, case-control study was conducted to compare the ability of pediatric residents to detect red reflex asymmetry in the specific disorders of anisometropia and microstrabismus using the Brückner reflex and the MTI photoscreener. This study was performed in accordance with the ethical standards of the institutional review board at our institution and with the Helsinki Declaration of 1975, as revised in 1983.

Twelve pediatric residents were trained in a hands-on instructional course on how to perform and interpret the Brückner reflex. With low room illumination, the residents were instructed to hold the direct ophthalmoscope at approximately 1 m (approximately 1 arm's length) from the patient, dial the large round light spot into

place, and use the lens system in the ophthalmoscope to focus on the child's corneas. Looking through the direct ophthalmoscope, they illuminated the pupillary red reflexes of both eyes of the patient simultaneously. After gaining the child's attention on the direct ophthalmoscope's light, the pediatric residents then compared the brightness and color of the red reflex in each eye. Test results were limited to a binary response of "abnormal" or "normal," indicating presence or absence of asymmetry of the red reflexes, respectively. Asymmetry of the red reflex was defined specifically as any noticeable difference in the brightness and/or color of the red reflexes of a single patient. As part of the instructional course, the pediatric residents reviewed multiple examples of symmetric and asymmetric Brückner reflex results (Fig 1). In addition, they were required to be able to distinguish a symmetric from an asymmetric Brückner reflex in several cooperative adults before participating in the study.

The residents then were taught to compare the red reflexes of both eyes of patients in the black and white MTI photographic images. The MTI photograph result consists of 2 photographs on 1 page. The photographs are taken with the flash oriented at 90° and 180°. In patients with anisometropia and microstrabismus, asymmetry can be present in 1 image or both images. When asymmetry of the brightness of the red reflexes was noted in either or both images, the result was to be interpreted as "abnormal." Several examples of MTI photographic images with symmetric and asymmetric pupillary reflexes were reviewed and analyzed by the residents in a practice session (Fig 2). The residents again were required to be able to distinguish symmetric from asymmetric reflexes before participation in the study.

Appropriate informed consent was obtained for all study patients and control patients before the study. The study patient group was composed of 10 patients (5 boys and 5 girls). The control group was composed of 6 subjects (5 girls and 1 boy). Five participants were white, 6 were Hispanic, 2 were Asian, and 3 were black. All participants were healthy and without dysmorphic

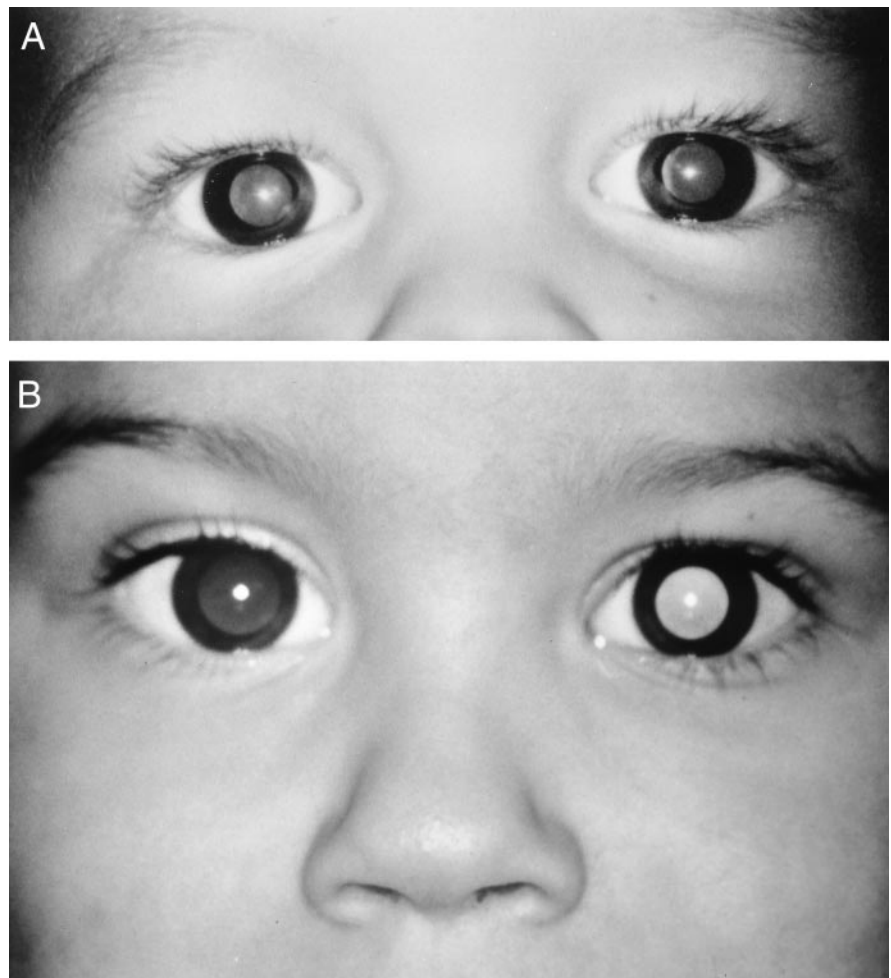


Fig 1. A, Brückner test demonstrating symmetry of the red reflexes. B, Brückner test demonstrating asymmetry of the red reflexes.

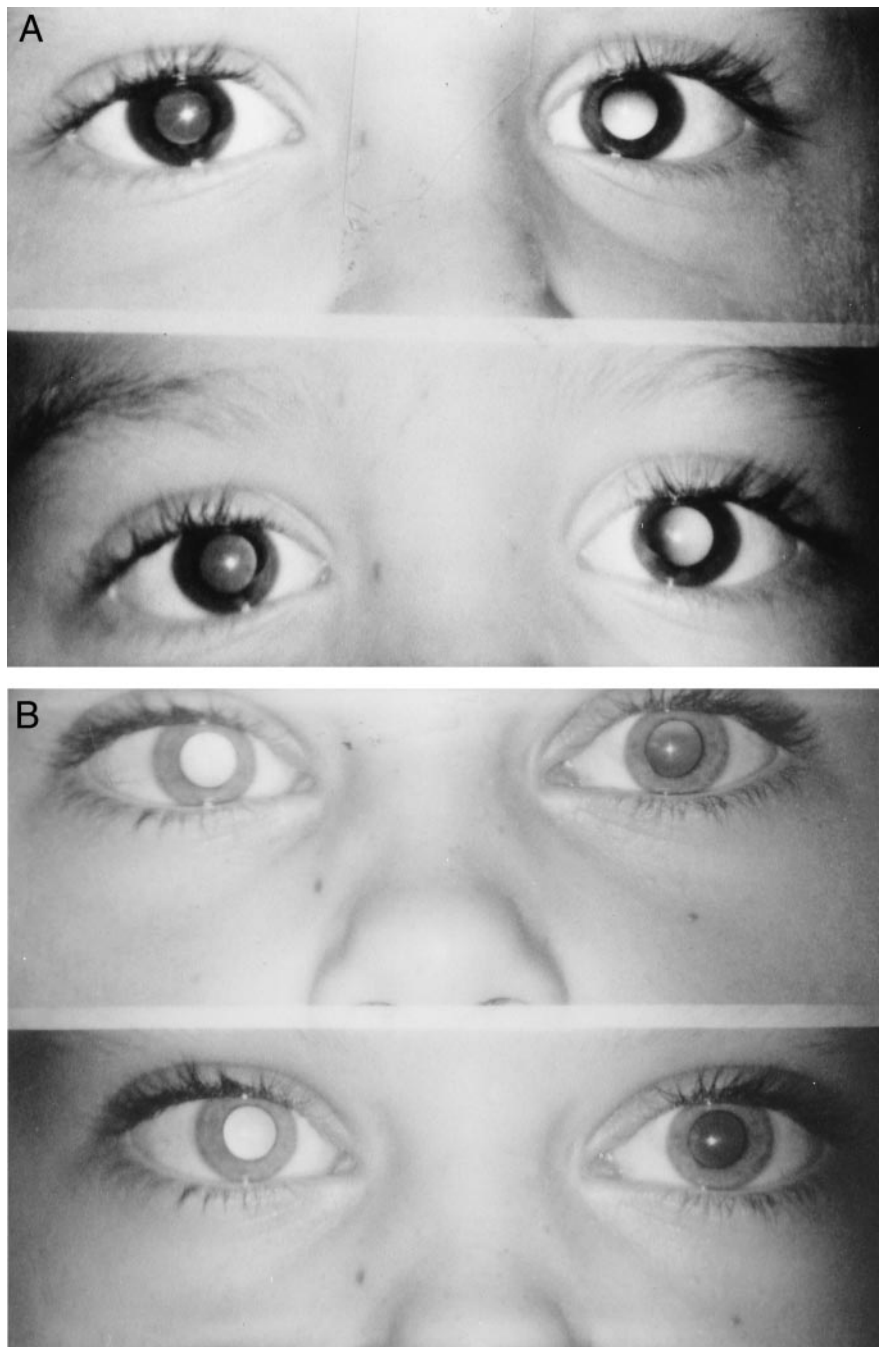


Fig 2. A, MTI photoscreener photograph demonstrating asymmetry of the red reflexes attributable to anisometropia. B, MTI photoscreener photograph demonstrating asymmetry of the red reflexes attributable to microstrabismus.

facial features that potentially could make Brückner reflex and/or photoscreening interpretation difficult. Four study patients had anisometropia, and 6 had microstrabismus.

All study patients and control subjects had received a comprehensive ophthalmologic examination by a pediatric ophthalmologist (E.A.P., D.K.C.) within 2 months of the study. All study patients and control subjects had to be cooperative for a Brückner test to be included in the study. In addition, all study patients and control subjects had either obvious asymmetric or symmetric red reflexes, respectively, on the Brückner reflex and the MTI photograph, as judged by 2 pediatric ophthalmologists (E.A.P., D.K.C.) (Table 1). Participants with obvious red reflex results were selected for this study because we first wanted to determine whether either of these screening tests was superior when the red reflex result was not subtle before performing this comparison on more subtle red reflexes.

Each child first was photographed with the MTI photoscreener (Model #PS45, MTI) immediately before the study according to the manufacturer's instructions. The photographs were taken in a

dimly lit room, with the patient's eyes undilated and without spectacle correction. The photographs were taken by one investigator (D.K.C.), who was experienced in the methods necessary to obtain accurate MTI images. Each photograph had to pass the manufacturer's quality guidelines to allow for accurate interpretation.

After the MTI photographs were obtained, each study patient or control subject was placed in a separate examination room. All participants who normally wore spectacles were instructed to remove them for the study because they would change the appearance of red reflex in Brückner reflex. The pediatric residents were masked as to the diagnosis of each participant. In random order, the residents first performed and interpreted a Brückner reflex on each of the 16 participants. During a separate testing period immediately after the Brückner reflex session, each resident evaluated randomly arranged masked MTI photographs of the same participants.

Sensitivity and specificity were calculated. Because the results

TABLE 1. Diagnostic and Refractive Data

Diagnosis	Participant Number	Age (Years)	Refractive Error	Spherical Equivalent Difference	Motility
Anisometropia	1	1.0	OD: -6.00 + 2.00 × 090 OS: -2.25 + 2.00 × 080	3.75	Ortho
	2	6.0	OD: +3.00 + 1.75 × 125 OS: +1.00 + 1.25 × 075	2.25	Ortho
	3	8.0	OD: +3.00 + 1.00 × 075 OS: +0.25 + 0.25 × 090	3.13	Ortho
	4	4.0	OD: -0.75 + 0.50 × 090 OS: +4.75 + 0.50 × 160	5.5	Ortho
Microstrabismus		Mean = 4.7		Mean = 3.65	
	5	6.0	OD: +1.25 sphere OS: +0.50 sphere	0.75	5 ET, trace DVD OU
	6	7.0	OD: +0.75 + 0.50 × 075 OS: +1.00 + 0.25 × 080	0.13	10 ET
	7	10.0	OD: +1.00 sphere OS: +1.00 sphere	0	6 ET, 9 LHT
	8	1.0	OD: +0.50 sphere OS: +0.50 sphere	0	8 ET
	9	5.0	OD: +0.50 sphere OS: +0.50 + 0.50 × 075	0.25	5 ET
Control		Mean = 5.3		Mean = 0.31	
	10	3.0	OD: +2.50 sphere OS: +3.00 + 0.50 × 090	0.75	10 ET
	11	2.0	OD: +0.25 + 2.50 × 090 OS: +0.25 + 2.75 × 090	0.17	Ortho
	12	9.0	OD: -1.00 sphere OS: -1.25 + 0.25 × 180	0.12	Ortho
	13	2.0	OD: -0.50 + 1.00 × 180 OS: -0.50 + 1.00 × 015	0	Ortho
	14	7.0	OD: +0.50 sphere OS: +0.50 sphere	0	Ortho
	15	1.0	OD: -2.00 + 1.50 × 180 OS: -2.00 + 1.50 × 180	0	Ortho
	16	7.0	OD: +0.50 + 0.75 × 090 OS: +0.25 + 0.75 × 090	0.15	Ortho
		Mean = 4.9		Mean = 0.07	

Ortho indicates orthotropia; ET, esotropia; DVD, dissociated vertical deviation; LHT, left hypertropia; OD, right eye; OS, left eye.

were on a nominal scale, comparison analysis was performed using the McNemar test.

RESULTS

The mean age was similar in all groups at 4.7 years (range: 1–8 years) for the anisometropia subgroup, 5.3 years (range: 1–10 years) for the microstrabismus subgroup, and 4.9 years (range: 1–9 years) for the control group. The mean difference in spherical equivalent between fellow eyes in the anisometropia subgroup was +3.65 (range: +2.25 to +5.50). In the microstrabismus subgroup, the strabismic deviation was horizontal in all patients except 1, who had a vertical deviation (Table 1).

Correct and incorrect resident responses from the

Brückner reflex and the MTI photoscreener photographs were referenced to the comprehensive ophthalmologic examination. The pediatric residents had a mean of 82% correct (range: 69%–100%) when using the MTI photoscreener, whereas they had a mean of 65% correct (range: 44%–81%) when using the Brückner reflex (McNemar test: $\alpha < 0.01$; Table 2). The sensitivity of the MTI photoscreener was 89% compared with 61% for the Brückner reflex. The specificities of the photoscreener and the Brückner reflex were 69% and 71%, respectively. When separated into the different subgroups of anisometropia and microstrabismus, the photoscreener test in the hands of pediatricians still was significantly better than the Brückner reflex in differentiating a normal

TABLE 2. Statistical Results

Diagnosis	Test Type	% Correct	Standard Deviation	Sensitivity	Specificity
Anisometropia	Photoscreener	100%*			
	Brückner Test	75%*			
Microstrabismus	Photoscreener	82%†			
	Brückner Test	51%†			
Control	Photoscreener	70%			
	Brückner Test	71%			
All combined	Photoscreener	82%* (69%–100%)	0.10	89%	69%
	Brückner Test	65%* (44%–81%)	0.12	61%	71%

* McNemar test: $\alpha < 0.01$.

† McNemar test: $\alpha < 0.001$.

from an abnormal result for these 2 amblyogenic risk factors (McNemar test: $\alpha < 0.01$ for the anisometropia group; $\alpha < 0.001$ for the microstrabismus group; Table 2).

DISCUSSION

Early recognition and treatment of amblyopia is critical to achieving an optimal visual outcome. The current recommendation from the American Academy of Pediatrics and the American Association for Pediatric Ophthalmology and Strabismus is for children to undergo a comprehensive examination of the visual system in the preschool years (ages 3–5) to detect amblyopia and other eye disorders.^{4,16} Many children, however, do not undergo this recommended comprehensive ophthalmologic examination. Therefore, sensitive and specific screening tests must be in place at schools and in primary care physicians' offices to aid in identification of children who are at highest risk for amblyopia to guide referral practices and encourage parents to seek ophthalmologic examination.

Vision screening using acuity-based targets typically begins between the ages of 3 and 5 years either in the school system or in primary care physicians' offices. Amblyopia that is detected at 5 years of age is much more difficult to treat and cure than amblyopia that is detected at 2 to 3 years of age. Therefore, detection of amblyopia at an earlier age, when treatment is easier and more effective, would be very beneficial. The problem with very early vision screening, however, is that many children either cannot or will not reliably identify the visual targets. The Brückner reflex and photoscreening are 2 methods that can be used to screen for amblyogenic risk factors in this group of preverbal and nonverbal children.

The Brückner reflex evaluates for asymmetry of the pupillary red reflexes as a screen for the potential amblyogenic risk factors of anisometropia, strabismus, or media opacity.^{6–8} An important advantage of the Brückner reflex is the ready availability of the necessary equipment in a pediatrician's office, requiring only a direct ophthalmoscope. However, the test is difficult to perform or interpret when patients are uncooperative and will not fixate on the ophthalmoscope, when the pupils are small, and when the retinas are darkly pigmented. This test also can be difficult to interpret if not performed routinely. Furthermore, Archer¹⁷ found that the Brückner reflex in infants who are younger than 8 months was not reliable, finding a high false-positive rate, possibly attributable to immature accommodation. All of these reasons may explain why the Brückner reflex is not used routinely in every pediatrician's office.

Photoscreening has become available recently as a means to screen verbal, preverbal, and nonverbal children for amblyogenic risk factors. Photoscreeners, such as the Brückner reflex, use the pupillary red reflexes to detect patients with potentially amblyogenic conditions. Photoscreening offers several theoretic advantages over the Brückner reflex. One advantage is that because the photoscreener unit is

portable and simple to use, the photographs can be taken off-site by a technician or a lay person and then reviewed later by trained readers in a centralized reading center. This could allow large-scale screenings to be done outside an office setting.¹⁸ Another advantage is that the photograph from the photoscreener is not a "moving target," in contrast to the live child with whom the examiner deals when interpreting the Brückner reflex. This feature allows the examiner unlimited time to evaluate the photograph.

Vision screening is a task performed routinely in schools, preschools, and pediatricians' offices. Ophthalmologists or other ancillary eye care specialists rarely perform vision screening. So, ideally, then, people who are most likely to be conducting vision screening tests should be the ones used to evaluate them for efficacy. We believe that the most important use of the Brückner reflex and photoscreening by vision screening personnel should be for detection of red reflex asymmetry, which can represent the most common and severe causes of amblyopia, namely anisometropia, strabismus, and media opacity. We do not believe that vision screeners need to determine the actual diagnosis with the screening test. Making a screening test or its interpretation too complex reduces examiner confidence and reduces its routine use. Because of these reasons, our study addressed the specific question of red reflex asymmetry detection using these 2 screening modalities. This study did not address the issue of high symmetric refractive error, a less common cause of amblyopia that does not cause red reflex asymmetry.

Most previous studies that evaluated photoscreeners found them to have varying potential to screen children accurately for amblyogenic risk factors. The sensitivity and specificity of photoscreener testing for the detection of specific amblyogenic risk factors in these studies ranged between 37% and 94% and between 40% and 90%, respectively.^{9–15} The weaknesses of most of these studies were the heterogeneous group of interpreters; the heterogeneous group of patient diagnoses; variability in photographic quality; and the difficult requirement that the interpreters determine the actual diagnosis of strabismus, anisometropia, ptosis, or media opacity.^{9–13,19,20} Furthermore, most of these studies used ophthalmologists, optometrists, and ophthalmologic researchers almost exclusively as the photographic interpreters.

Our sensitivity and specificity results of 89% and 69% for the MTI photoscreener were on the higher side of these previously published results. We acknowledge that these results may be higher than those in other publications because 1) we only used 2 participant groups, 1 with obvious symmetric and the other with obvious asymmetric red reflexes; 2) this was not a large-scale screening environment; 3) we limited the interpreters to a homogeneous group of pediatric residents; and 4) we simplified the interpretation by requiring only the determination of symmetry or asymmetry of the red reflexes to detect only the 2 most common amblyogenic risk factors, anisometropia and microstrabismus. We believe,

however, that this scenario more accurately reproduced a true screening environment where busy pediatricians actually work and probably more accurately represents a real-world situation. We acknowledge that these results probably would change somewhat in a large-scale population.

Gole and Douglas²¹ reported sensitivity and specificity results for the Brückner reflex of 86% and 65%, respectively, when performed by a medical student. The sensitivity result for the Brückner reflex found in their study was better than our sensitivity result of 61%. However, it is important to understand that our study was designed differently and addressed different issues, which may account for this difference. The purpose of Gole and Douglas's study was to validate the use of the Brückner reflex to screen for amblyogenic risk factors. They used 1 observer and many more study participants. Therefore, a learning effect may have accounted for the higher sensitivity found in their study. The purpose of our study, conversely, was not to validate the Brückner reflex or the MTI photoscreener test. The purpose of our study was to compare the ability of multiple pediatric residents to differentiate symmetric from asymmetric red reflexes using these 2 screening modalities.

It is important to remember that this study evaluated the Brückner reflex and the MTI photoscreening photograph only with regard to the 2 amblyogenic risk factors of anisometropia and microstrabismus. High symmetric refractive error, which is a potential amblyogenic risk factor, will not be detected using red reflex asymmetry with either of these tests. Fortunately, bilateral ametropic amblyopia resulting from high refractive error is not very common and the resulting amblyopia usually is milder than other forms of amblyopia. Last, high hyperopia, the condition in which most ametropic amblyopia occurs, commonly is associated with esotropia, which easily is detectable using either the Brückner reflex or the MTI photograph.

We found that the pediatric residents were significantly better at detecting an abnormal screening result (higher sensitivity) when using the MTI photoscreener than the Brückner reflex. This was true both for comparing disease to nondisease and when the participant group was subdivided into the diagnoses of anisometropia and microstrabismus. We can interpret this to mean that fewer patients with these specific amblyogenic risk factors would be missed (low false-negative result) when a pediatric resident uses the MTI photoscreener test than when he or she used the Brückner reflex.

Although our sensitivity result for the MTI photoscreener was good, our specificity result was marginal, allowing approximately a 30% overreferral rate. This overreferral rate has the potential to overwhelm the ophthalmologic community with normal examinations. Lower than desirable specificity rates, however, are a common problem with all currently available vision screening tests.^{18,22} The problem with the MTI photoscreener and most vision screening programs is that it screens for the risk factors of amblyopia, not amblyopia itself. One must evaluate

this specificity result in the proper context of what the alternative is: no consistent vision screening in preverbal children. MTI photoscreening potentially allows earlier referral of patients who have the specific amblyogenic risk factors of anisometropia and microstrabismus, which may lead to earlier and more effective treatment of amblyopia. We believe that this is a better option than the alternative of doing nothing. Additional work needs to be done, however, to improve the specificity of photoscreening and any other sort of vision screening method.

Age varied widely in our study and control groups (1–10 years), and it is known that age can be an important variable when using either the Brückner reflex or the MTI photoscreener, perhaps because cooperation is important for obtaining an accurate result. We believe that this variability in age did not hinder our results because an inclusion criterion for study patients and control subjects was cooperation for Brückner reflex testing by the pediatric ophthalmologist during the comprehensive examination. In addition, all study patients and control subjects had obvious asymmetric or symmetric red reflexes by Brückner reflex and MTI photoscreener as judged independently by 2 pediatric ophthalmologists.

CONCLUSION

Pediatric residents were better at detecting asymmetric red reflexes in individuals with the common amblyogenic risk factors of anisometropia and microstrabismus using the MTI photoscreener images than when interpreting the Brückner reflex. Although not specifically tested, we believe that by simplifying test interpretation to the binary response of "abnormal" or "normal" and using only nonophthalmic interpreters, we simulated a more realistic screening scenario. Because photoscreening can be used in preverbal and nonverbal children, broader use of photoscreening could lead to earlier detection and treatment of amblyogenic risk factors, possibly leading to better long-term visual outcomes.

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REFERENCES

1. Ehrlich MI, Reinecke RD, Simons K. Preschool vision screening for amblyopia and strabismus. Programs, methods, guidelines. *Surv Ophthalmol.* 1983;28:145–163
2. Flynn JT. Amblyopia revisited. *J Pediatr Ophthalmol Strabismus.* 1991;28:183–201
3. Tychsen L. Binocular vision. In: Hart WM Jr, ed. *Adler's Physiology of the Eye: Clinical Application.* 9th ed. St Louis, MO: Mosby Yearbook; 1992: 837–838
4. Coats D, Jenkins R. *Vision Assessment of the Pediatric Patient.* Refinements, American Academy of Ophthalmology. 1997;1:1
5. Hillis A, Flynn JT, Hawkins BS. The evolving concept of amblyopia: a challenge to epidemiologists. *Am J Epidemiol.* 1983;118:192–205
6. Tongue AC, Cibis GW. Brückner test. *Ophthalmology.* 1981;88:1041–1044
7. Cibis GW, Waeltermann JM. Rapid strabismus screening for the pediatrician. *Clin Pediatr.* 1986;25:304–307
8. Arnold RW. Vision screening in Alaska: experience with enhanced Brückner test. *Alaska Med.* 1993;35:212–215

9. Ottar WL, Scott WE, Holgado SI. Photoscreening for amblyogenic factors. *J Pediatr Ophthalmol Strabismus*. 1995;32:289–295
10. Preslan MW, Zimmerman E. Photorefraction screening in premature infants. *Ophthalmology*. 1993;100:762–768
11. Cooper CD, Bowling FG, Hall JE, et al. Evaluation of photoscreener instruments in a childhood population, 1 Otago Photoscreener and Dortmunds videophotorefractor. *Aust N Z J Ophthalmol*. 1996;24:347–355
12. Molteno ACB, Hoare-Nairne J, Sanderson GF, et al. Reliability of the Otago Photoscreener, a study of a thousand cases. *Aust N Z J Ophthalmol*. 1993;21:257–265
13. Freedman HL, Preston KL. Polaroid photoscreening for amblyogenic factors: an improved methodology. *Ophthalmology*. 1992;99:1785–1795
14. Kennedy RA, Sheps SB. A comparison of photoscreening techniques for amblyogenic factors in children. *Can J Ophthalmol*. 1989;24:259–264
15. Tong PY, Enke-Miyazaki E, Bassin RE, et al. Screening for amblyopia in preverbal children with photoscreening photographs. *Ophthalmology*. 1998;105:856–863
16. The American Association of Pediatric Ophthalmology and Strabismus. Eye care for the children of America. *J Pediatr Ophthalmol Strabismus*. 1991;28:64–67
17. Archer SM. Developmental aspects of the Brückner test. *Ophthalmology*. 1988;95:1098–1101
18. Donahue SP, Johnson TM, Leonard-Martin TC. Screening for amblyogenic factors using a volunteer lay network and the MTI photoscreener. Initial results from 15,000 preschool children in a statewide effort. *Ophthalmology*. 2000;107:1637–1644
19. Howland HC, Braddick O, Atkinson J, Howland B. Optics of photo refraction, orthogonal and isotropic methods. *J Opt Soc Am (A)*. 1983; 73:1701–1708
20. Wesemann W, Norcia AM, Allen D. Theory of eccentric photorefraction (photoretinoscopy): astigmatic eyes. *J Opt Soc Am (A)*. 1991;8:2038–2047
21. Gole GA, Douglas LM. Validity of the Brückner reflex in the detection of amblyopia. *Aust N Z J Ophthalmol*. 1995;23:281–285
22. Simons BD, Siatkowsky RM, Schiffman JC, et al. Pediatric photoscreening for strabismus and refractive errors in a high-risk population. *Ophthalmology*. 1999;106:1073–1080

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