

COMPARISON OF MTI PHOTOSCREENING TO VISUAL EXAMINATION OF CHINESE-AMERICAN PRESCHOOL CHILDREN

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Abstract

Thirty-nine Chinese-American preschool children were examined with the Medical Technology and Innovations (MTI) Photoscreener prior to a non-cycloplegic (dry) visual examination. For each child, two complete sets of photoscreening pictures were taken in succession and preceded the visual examination. Masked failure lists were compared and the readable photographic yield was evaluated. Twelve children failed the photoscreening, and fourteen failed the visual examination. Eleven children were common to both groups. Sensitivity measures varied from 72.7% to 80%. Specificity varied from 95.2% to 95.8%. False-negative findings were from 11.5% to 13%, and false-positive findings were from 8.3% to 11.1%. Yield varied from 79.5% to 100%. We conclude that the MTI is designed as a screening instrument and does not replace the need for a thorough visual examination. The photos must be carefully evaluated. In order to increase effective screening, an evaluation of readability should be made before the child is dismissed. Where the photo is questionable, another photo should be taken. Multiple photographs increased the readable yield. Overall the MTI Photoscreener compared favorably to the dry visual examination of our thirty-nine preschool children; how-

ever, there still existed an over and under referral rate of approximately 10%.

Key Words

analytic measures, masked comparison, MTI Photoscreener, readable yield, visual examination

Introduction

The Medical Technology and Innovations (MTI) Photoscreener is commercially manufactured to detect the major risk factors of amblyopia, including strabismus, refractive errors, and ocular abnormalities.¹ Figures 1-3 depict the instrument and measuring tool. The instrument has the potential to detect amblyogenic factors in a quick and noninvasive manner.²⁻¹⁰ The MTI takes flash photographs of the two primary meridians of each eye. These two sets of photographs are printed, one below the other, on one photographic plate. The light reflected from the retina is captured on Polaroid #337 film and is evaluated for refractive errors, strabismus, and media opacities. Refractive errors are detected by analyzing the crescent size and location. Crescents superior or to the viewer's left indicate myopia. Crescents inferior or to the viewer's right indicate hyperopia. A difference in magnitude of the crescents between the upper and lower photographs of each eye indicates astigmatism. Differences in crescent size between the two eyes indicate anisometropia. Figures 4-9 are actual photographs to illustrate several



Figure 1. Examiner's view of the MTI.



Figure 2. Patient's view of the MTI.



Figure 3. The MTI measuring tool.



Figure 4. Normal

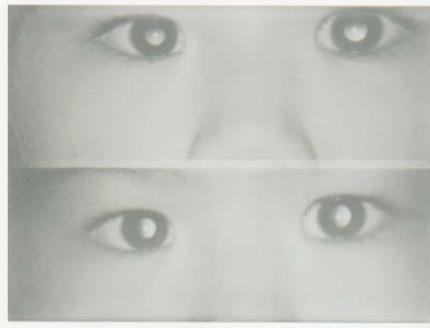


Figure 5. Hyperopia



Figure 6. Astigmatism

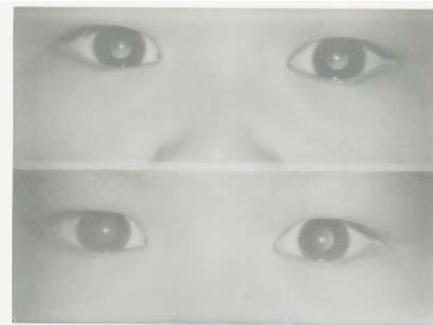


Figure 7. Anisometropia: OD Astigmatism, OS Hyperopia

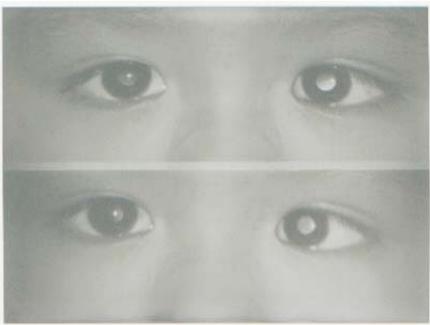


Figure 8. Esotropia



Figure 9. Unreadable due to fixation shift

different conditions. Strabismus is evaluated by corneal reflexes or color differences between the eyes. The reader can consult the MTI manual for further photographic instructions and interpretations, including detection of media opacities.¹

The primary aim of this study was to evaluate the sensitivity and specificity of the MTI Photoscreener in Chinese-American preschool children and to determine if two photographs change the analytical measures and yield as compared to one photograph per child.

Method

Thirty-nine Chinese-American preschool children received a photoscreening prior to a non cycloplegic (dry) visual examination. The children's ages ranged from 42-72 months. Of the 39 children, 20 were male and 19 were female. The MTI Photoscreener was used to take two sets of successive photographs. Each photograph requires two flashes, one of each major meridian. Therefore, a total of four flashes are required for two sets of photographs.

The MTI Photoscreener instruction manual¹ was used as a guide for interpreting the photographs. Investigator DF did the evaluation of the photographs. Each photo was carefully evaluated for picture clarity, pupil visibility, structural abnor-

mality, fixation, pupil size, corneal light reflex and brightness, and refractive crescent. The MTI pupil-crescent measurement tool (Figure 3) was used for all measurements. Photos with poor clarity or poor pupil alignment and photos with "off center" target fixation were excluded from further interpretation. In accordance with the instruction manual, photos of children with pupil sizes less than 4mm or greater than 8mm were also excluded. The remaining photos were evaluated for structural abnormalities, binocular misalignment or refractive condition. Criteria for failure conformed to the MTI manual instructions.

The visual examination followed the photoscreening. Resident doctors provided care in one of four stations. The first station was distance and near visual acuity. The second station was external eye health, eye movements, distance and near cover tests, near point of convergence and stereoacuity. The third station was color vision testing using Color Vision Testing Made Easy,^a and the fourth station evaluated the ocular fundi by monocular indirect ophthalmoscopy or direct ophthalmoscopy. Pediatric attending faculty doctors (IC and RH) performed dry retinoscopy at the fifth station. When ab-

errant results occurred at any of the four stations, one of these two attending doctors revisited the test. They also reviewed all examination records before the children were dismissed. Though each child was given a permission form for authorization to use mydriatic and cycloplegic eyedrops, few parents consented.

The criterion for failure of the visual examination were: monocular visual acuity less than 20/30, any suspected ocular pathology, restriction of an extraocular muscle, strabismus, a phoria greater than 8^Δ at distance and/or near, a nearpoint of convergence more receded than 4 inches, absence of Randot stereoacuity, failure on the Color Vision Test Made Easy,^a or any potentially amblyogenic refractive condition. The refractive criteria were in conformity with the AOA Practice Guidelines.¹¹⁻¹³ At the conclusion of the visual examination, appropriate intervention and treatment were instituted.

Results

Twenty-four children passed our testing. The data we present are for the 15 children who failed either the photoscreening, the visual exam, or both.

Two masked failure lists were independently generated from the failures of the MTI Photoscreenings and the visual

Patient	Photo	Reason	Exam	Reason
5	P		F	Exotropia
6	F	Astigmatism	F	Astigmatism
7	F	Esotropia	F	Esotropia/Aniso
8	F	Astigmatism	F	Astigmatism
13	F	Astigmatism/Aniso	F	Amblyopia/Astigmatism/Aniso
14	F	Astigmatism	F	Astigmatism
15	F	Myopia	F	Mixed Astigmatism
17	F	Esotropia/Hyperopia	F	Esotropia/Hyperopia
18	P		F	Astigmatism/Aniso
19	F	Hyperopia	F	Hyperopia
25	F	Esotropia	F	Reduced VA @ near
26	F	Astigmatism	F	Astigmatism
35	P		F	Compound Hyperopic Astigmatism
36	F	Astigmatism	P	
38	F	Esotropia	F	Optic Nerve Anomaly

Analytic Measure	Photo 1	Photo 2	Photo 1or 2	Photo 1and 2
Sensitivity	72.7%	76.0%	80.0%	78.5%
Specificity	95.2%	95.6%	94.4%	95.8%
False negative	13.0%	12.0%	10.5%	11.5%

	Photo 1	Photo 2	Photo1=2	Photo1+2
Yield	31/39	35/39	9/13	39/39
%	79.5%	89.7%	69.2%	100%

examinations. The reasons for failures are listed in Table 1. Twelve children failed the photoscreening, and fourteen failed the visual examination. Eleven children were common to both groups. Of those who did not fail both, one failed the photoscreening for astigmatism (patient 36), and three failed the visual examination, for astigmatism (patient 18), compound hyperopic astigmatism (patient 35), and intermittent exotropia (patient 5). When the photos of these three patients were reviewed, two children had pupil sizes of slightly greater than 4mm, which is the minimal size necessary for photography interpretation, and the other had a potentially amblyogenic amount of astigmatism, but this amount is below the minimal refractive error detectable by the MTI.

The analytic measures of sensitivity, specificity, false-negative and false-positive were calculated (Table 2).^{8,14} The sensitivity measurement identifies subjects having an abnormality where one exists. Selectivity identifies a subject, as being “normal” and the subject is “normal”. A

false-negative finding indicates that the subject is free of the abnormality when the subject has the abnormality. Conversely, a false-positive test result identifies a subject as having the abnormality when he/she does not have it. These measures were calculated for the various photographic yields. A detailed discussion of these measures are in the text *Designing Clinical Research*.¹⁴

Photographs were considered readable if they matched the previously described manual criteria. All other photographs were excluded from further evaluation. If only the first picture (photo 1) was successfully evaluated, the readable photographic yield was 79.5%. If only the second picture (photo 2) was successfully evaluated, the yield was 89.7%. If both pictures (photo 1+2) were successfully evaluated for at least one acceptable photo, the yield was 100%. There were 27 sets of photos in which both pictures (photo 1=2) were readable and in agreement, resulting in a yield of 69.2% (Table 3).

Discussion

Chinese children have a predominance of with-the-rule astigmatism,^{15,16} with a rapid decrease in the amount of astigmatism by the first year of life.¹⁷ This is in contrast to a high prevalence of against-the-rule astigmatism in Caucasian children, with a decrease in magnitude over the first two years of life.¹⁸ Eight out of 15 children who failed (53.3%) in our study showed the expected predominance of with-the-rule astigmatism. Additionally, Chinese infants show a rapid decrease in anisometropia, with a low prevalence by 9 months of age.¹⁹ In our study, three out of 39 children (7.7%), had anisometropia (Table 1). Since myopia is not usually present until the age of six years or older,²⁰ the major usefulness of photoscreening in preschool children would be to detect hyperopia and astigmatism. However, this may not be totally the case for Chinese preschoolers. Chan and Edwards suggest the referral criteria be set at a minimum of +2.00D of hyperopia, -1.00D of myopia, -1.00D of astigmatism and 1.25D of anisometropia.²¹

There are several potential limitations of the MTI that may affect the accuracy of the photoscreening results. The limitations are:

1. the existence of a null interval
2. the failure to detect lower amounts of hyperopia
3. the time lag between flashes
4. the child's understanding of the instructional set
5. the effect of fixation shift
6. the inability to detect certain posterior segment pathology
7. the constraints of pupil size and fundus pigmentation
8. the variability of photographic interpretation

The MTI manual speaks of the “null interval,” which is defined as +1.00D to -0.75D.¹ The camera is not sensitive enough to detect this amount of refractive error. Therefore, a patient could have +1.00 D in one major meridian and -0.75 D in the other meridian and the MTI photograph will lack a crescent large enough to indicate 1.75D of astigmatism. This scenario occurred with patient 35. Additionally, since only the major meridians are photographed, an oblique cylinder can potentially be undetected.

Tong et al. noted that most children with 2.00D to 3.50D of hyperopia were

not identified by photoscreening.⁶ Chan and Edwards, in their study of Hong Kong preschool children, concluded that esotropias were associated with hyperopia of 2.00D or more.²¹ Since the children we examined did not undergo cycloplegic visual examinations, these conditions could have been missed by both visual examination and photoscreening. Nevertheless, the visual examinations included cover testing and visual acuities, which should have detected the presence of esotropia and refractive amblyopia.

As discussed earlier, each Polaroid plate contains two pictures. The first flash captures the horizontal meridian and the second captures the vertical one. The MTI accomplishes this by an automatic 90° rotation of the strobe from a horizontal to a vertical orientation. There is a 3-4 second time lag between the first picture and the instrument's ability to take the second picture. In this interval a child can change his level of accommodation, resulting in the comparison of crescents of two different refractive states.

The MTI Photoscreener uses a target pattern, which for a valid picture requires the subject to fixate the brighter center red light (Figure 2). To encourage proper fixation, the examiner can activate a musical tone button. An instructional set, such as "I am going to take your picture; look at the middle of the bright red light," is employed to encourage fixation on the center red light. Receptive language difficulties, secondary to young age, developmental delays, or difficulty with English, can interfere with a valid photo yield. Watts, Walker and Beck used the MTI to evaluate children and young adults with severe learning problems.³ The mean age of their subjects was 10 years with a range of 3 to 18 years. Though the sensitivity and specificity percentages were both at least 90%, the first photo readable yield was only 26.3%. Multiple photos were required to achieve readable photographs. The average number of photographs per subject was slightly over 2 with a range of 1 to 4.³

Recently Miller et al reported on the ability of an interpreter to detect improper fixation.²² In this study the subjects deliberately aligned and misaligned their eyes from the center fixation target, resulting in on-axis and off-axis photographs. The raters correctly identified proper fixation 73% of the time. They could routinely interpret off-axis fixation if it was 10 cm or

greater, but correct identification of 5 cm of off-axis fixation, either horizontally or vertically, ranged from 32% to 47%. It was also noted that an increase in off-axis fixation was associated with an increase in the refractive crescent, which would increase false positive findings.²²

The MTI may be able to detect opacities in the media as well as certain alterations of the retinal pigment. In our sample, one child, patient 38, had a questionable optic nerve presentation. If just the MTI had been used, this would have been missed. Pupil size can also be critical to successful interpretation. A pupil greater than 4mm or less than 8mm is needed for valid results. Further, fundus pigmentation can make photo interpretation more difficult.¹ It is reasonable that a dark fundus in combination with a minimally qualifying pupil could make interpretation more difficult. This was the case for two of our subjects, patients 18 and 35, resulting in two false negatives.

Photograph interpretation and validity have been examined by a number of investigators.^{2,3,7-9} Sensitivity measures have ranged from 65% to 93%, while specificity measures have varied from 62% to 91%. In these studies the number of photo interpreters varied from two to more than six. The interpreters ranged from pediatric ophthalmologists to non-professionals, and their experience in photo interpretation varied from novice to experienced. There were varied intra and inter group results, exemplifying how interpretation can influence the ability of photoscreening to detect visual anomalies. Additionally, training has been found to be helpful in acquiring greater interpretive abilities.^{23,24}

Interpretation of the MTI photographs requires a level of expertise in order to correctly match the manufacturer's photograph interpretation criteria. In our study, the amount of time needed to critically examine the photographs was more than a cursory viewing. For maximal accuracy, the photographs must be critically evaluated. We agree with previous studies stating that even experienced practitioners may have difficulties meeting the criteria established by MTI for evaluating the photographs. Training is recommended to improve reliability of photograph interpretation. We feel this is especially true for our subject population, Chi-

nese-American preschoolers, with dark irides and fundi.

Two limitations of our data are that the refraction was not cycloplegic, and the sample size was small. Permission for the examinations was obtained by written consent. In almost all cases, the parents, who were at work and not present for the examination, did not give permission to use eye drops. Therefore, we examined these children in the absence of their parents. In a situation with very young children in the absence of their parents and no cycloplegic agents used, we made attempts to control subject fixation using a variety of techniques, including having the subject view a videotape while performing distance retinoscopy. When many factors are not under the control of the examiner, accurate refraction may be difficult. The MTI, with its relative ease of use, is definitely a good option for screening for amblyogenic factors, particularly significant refractive errors. However, we caution that the interpretation of the photographs, which is equally if not more important than taking an adequate photograph, requires a skilled interpreter.

Conclusion

The MTI Photoscreener is designed as a screening instrument and does not replace the need for a thorough visual examination. The MTI is designed to detect hyperopic, myopic, and astigmatic refractive errors, which are prevalent in preschool children. However, the MTI can miss intermittent strabismus and various posterior segment pathologies. In order to increase effective screening, an evaluation of photographic readability should be made before the child is dismissed. In cases where the photo is questionable another photo should be taken. Multiple photographs will increase yield. Overall the MTI Photoscreener compared favorably to the dry visual examination of our thirty-nine preschool children; however, there still existed an over and under referral rate of approximately 10%.

Drs. Chung, FitzGerald and Hughes have no financial interest in the Medical Technology and Innovations (MTI) Photoscreener.

Source

- a. Color Vision Testing Made Easy
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Date accepted for publication:
December 10, 2001