Comparison of Eccentric Fixation Measurements Using the Streak Target of an Ophthalmoscope and a Traditional Visuoscopy Target

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ABSTRACT

Purpose: To compare measurements of eccentric fixation using two different targets for fixation, a traditional visuoscope target and the streak target of an ophthalmoscope.

Patients and Methods: Monocular fixation was evaluated using visuoscopy in 47 patients ranging in age from 4 months to 22 years. Visuoscopy measurements were compared using both the traditional visuoscope target and the streak target of a Welch Allyn ophthalmoscope. The streak light was rotated both horizontally and vertically to detect both horizontal and vertical eccentric fixation.

Results: The streak target improved testability of eccentric fixation in children younger than 3 years compared to the traditional visuoscope target (75% versus 30%). All of the patients older than 3 years were testable using both targets, with both methods yielding the same results. All of the patients with a visual acuity of at least 20/20 also demonstrated central fixation using both techniques.

Conclusions: Using the streak of a Welch Allyn ophthalmoscope as a visuoscope target allows for testing of eccentric fixation in children younger than 3 years.

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INTRODUCTION

Measurement of monocular fixation is important in the diagnosis and treatment of amblyopia.[1,2] Eccentric fixation is present in approximately 44% of all patients with amblyopia[3] and in 30% of patients with strabismic amblyopia.[4] Although there is no exact relationship between eccentricity and visual acuity,[3-6] generally the farther away from the fovea that patients fixate, the greater the decrease in visual acuity.[3,7-9] In addition, fixation becomes increasingly unsteady the farther away fixation is from the fovea.[3,8] It has been assumed that as visual acuity improves during treatment, fixation will move closer to the fovea. Thus, measuring the trend of monocular fixation may be useful in assessing the effectiveness of treatment.

Amblyopia associated with anisometropia and strabismus is easily identified. However, reduction of visual acuity without an obvious strabismus or anisometropia may be more difficult to identify, partic-

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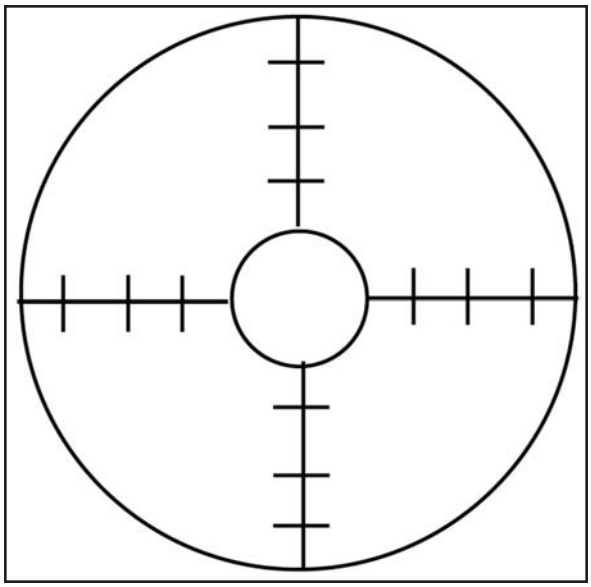

Figure 1. With the traditional visuoscope target, patients are asked to fixate the central circle while the examiner denotes the position of the circle relative to the fovea.

ularly if the amblyopia is a result of microtropia. In this article, microtropia is defined as no movement on a unilateral cover test with eccentric fixation in the amblyopic eye. Thus, microtropia occurs when the objective angle is equal to the magnitude of the eccentric fixation, and there will be a positive 4-prism diopter (PD) test. A diagnosis of microtropia can only be confirmed with the demonstration of eccentric fixation via visuoscopy or entoptic phenomenon, which denotes the position of the fovea as compared to the exact position of fixation. The discovery of microtropia has served as the missing link whereby eccentric fixation is associated with sensory deprivation that causes amblyopia in children with seemingly nonstrabismic eyes and relatively isometropic refractive errors.

Entoptic methods of evaluating fixation require a verbally mature patient to give appropriate responses. Consequently, entoptic testing is not useful for patients younger than 4 years. It is generally agreed that the prognosis for correction of amblyopia in the visually immature is improved when treatment is begun early.[1,10] Hence, it is important to identify amblyogenic factors in young patients. Large-angle strabismus and clinically significant anisometropia are both relatively easy to ascertain in children older than 6 months without the use of sophisticated testing techniques. However, microtropia and eccentric fixation remain difficult to diagnose in young, nonverbal children.

The most common method for determination of eccentric fixation is with a visuoscope. The original visuoscope was designed by Cuppers.[2,5] With traditional visuoscopy, a target is projected onto the retina, and the examiner asks the patient to look directly at the center of the circle. The examiner then observes the point on the retina used for fixation.[2,11] This objective test provides clinicians with direct observation of the fixation point of the eye.[6] It requires patients to voluntarily fixate the target and assumes the foveal reflex accurately demarcates the center of the foveal clivus.

We describe an alternative objective method of determining eccentric fixation. Instead of using the traditional visuoscope target found in direct ophthalmoscopes, we used the streak aperture of the Welch Allyn ophthalmoscope. One of the authors (J.C.) noted children younger than age 6 years are reflex bound whereby they automatically fixate the center of a direct ophthalmoscope light. Thus, when a light is placed on the retina of a young child, it is assumed the child will fixate the center of the light with the fovea if central fixation is present, and a decentered foveal reflex will occur if fixation is eccentric. In this study, we compared measurements of fixation (both normal and eccentric) using the streak target and the traditional visuoscope target of the Welch Allyn monocular direct ophthalmoscope.

Patients and Methods

Forty-seven patients ranging in age from 4 months to 22 years were examined for the presence of eccentric fixation at either a private pediatric ophthalmology practice or at the University Optometric Center, State University of New York (SUNY), College of Optometry, for the presence of eccentric fixation using visuoscopy. The study was approved by the Institutional Review Board of the SUNY College of Optometry.

Patients with amblyopia were classified according to their etiology: strabismic, refractive, or both. The strabismic group included patients with horizontal, vertical, and microtropic deviations. Visuoscopy was performed with both the traditional visuoscope target (Fig. 1) and the streak target of a Welch Allyn direct ophthalmoscope (Fig. 2). Both targets were set at the lowest illumination, which

allowed observation of the macula without dazzling the patient during testing. The traditional visuoscope target has reticule lines placed at 1-PD intervals; the streak target also is approximately 1 PD in width.

Assessment was performed with and without dilation. If the pupil was too small to perform with either procedure and the parent refused dilation, the child was excluded from the study. Examiners were masked to patients' visual acuity and binocular status. Patients with ocular pathology that could potentially interfere with visual acuity were excluded from the study.

The order in which examiners performed visuoscopy with either the traditional visuoscope target or the streak target was randomly determined. Fixation was classified by magnitude, direction, and degree of centration. For the traditional visuoscope, patients were instructed to "look directly at the center of the small circle," and the relationship of the foveal reflex to the target was recorded. For the streak target, the horizontal streak of light was used to measure vertical eccentric fixation and the vertical streak was used for horizontal eccentric fixation. Because there are no lines to measure the distance exactly, examiners estimated the distance of the fovea from the center of the streak (1 PD in width).

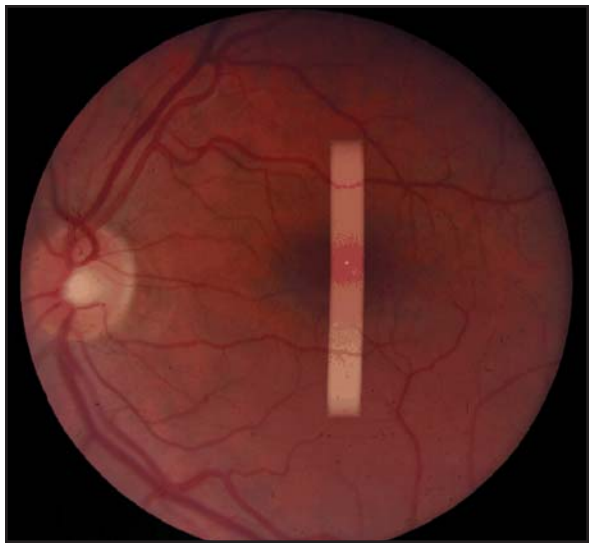

Figure 2. With the streak target technique, using a Welch Allyn ophthalmoscope, patients are asked to look at the streak of light, which is projected both horizontally and vertically. Young children reflexively look at the streak. The relative position of the streak to the foveal reflex denotes fixation.

Results

The Table presents findings for each patient. Twenty-two patients had amblyopia, 17 had anisometropia, 12 had eccentric fixation, 17 had strabismus, and 18 had normal binocular vision. Some patients had more than one diagnosis. All of the patients who had eccentric fixation identified by one procedure demonstrated eccentric fixation with the other procedure, and all of the patients who had central fixation with one procedure also had central fixation with the other procedure.

Ten patients (20 eyes) were between the ages of 4 months and 3 years. Fifteen of the 20 eyes fixated the streak target, while only 6 of the 20 eyes were able to fixate the traditional visuoscope target (Fig. 3). The youngest patient (4 months old) was frightened during testing with both fixation targets; however, the foveal reflex was seen centrally with the streak target but not with a traditional visuoscope. A diagnosis of central fixation was made.

Any patient younger than 3 years who was able to fixate the visuoscope target also fixated the streak target (such as patients 5, 8, and 10). However, the converse was not true: 75% of patients younger than 3 years fixated the streak target, which resulted in the determination of monocular fixation status, while only 30% of patients younger than 3 years were able to fixate the traditional visuoscope target. After age 3 years, there was no statistically significant difference between using the streak target or the traditional visuoscope target to identify eccentric fixation; thus, all patients older than 3 years were testable with either technique (Fig. 4).

Discussion

Amblyopia, which occurs in 3% to 5% of the population, is a major public health issue. It causes more visual loss in patients younger than 40 years than all ocular disease and trauma combined together.[12] Early diagnosis and treatment are important in the amelioration of amblyopia.

A traditional pediatric eye examination, which includes cover testing and a cycloplegic refraction, allows skilled eye care professionals to detect amblyopia associated with anisometropia as well as small-angle strabismus. However, microtropia and its associated amblyopia may go undiagnosed with this testing battery. Sensitivity for detecting ambly-

TABLE

PATIENT FINDINGS WITH TRADITIONAL VISUOSCOPE AND STREAK TARGETS

Patient No.	Age (y)	Eye	Refraction	Visual Acuity	Diagnosis	Streak	Visuoscope	Comments
1	0.4	Right	+1.50	Unable	Hyperopia	CU	Unable	Patient frightened with both
		Left	+1.50	Unable		CU	Unable	
2	1.1	Right	+2.00	Unable	Hyperopia	CU	Unable	Readily fixated streak; uninterested in visuoscope
		Left	+2.00	Unable		CU	Unable	
3	1.2	Right	+1.50	Unable	Hyperopia	Unable	Unable	Patient frightened of lights
		Left	+1.50	Unable		Unable	Unable	
4	2.4	Right	+0.50	Unable	Hyperopia	CU	Unable	Easier with streak
		Left	+0.50	Unable		CU	Unable	
5	2	Right	+2.00	Unable	Hyperopia	CU	CU	Fairly uncooperative; easier with streak
		Left	+2.00	Unable		CU	CU	
6	2.4	Right	+3.25-1.25X180	Unable	Hyperopia	Unable	Unable	Patient looked at both but had difficulty fixating
		Left	+3.25-1.25X180	Unable	Astigmatism	Unable	Unable	
7	2.5	Right	+1.50-0.75X008	20/30	Alt ET	CS	Unable	Easier with streak; lost interest with visuoscope
		Left	+1.75-0.50X172	20/30		CS	Unable	
8	3	Right	+2.50-3.50X007	20/30	Hyperopia	CS	CU	Easier with streak
		Left	+1.50-1.75X016	20/30	Astigmatism	CS	CU	
9	3	Right	+2.00-0.50X076	Unable	LET	Unable	Unable	Patient uninterested
		Left	+3.25	Unable		CU	Unable	
10	3	Right	+2.00	20/20	Alt ET	CS	CS	Equal with both
		Left	+2.50	20/20		CS	CS	
11	3.1	Right	+5.00	20/40	20 XT s/p surgery	CS	CU	Equal with both
		Left	+5.50	20/40		CS	CU	
12	3.5	Right	+4.00-1.00X180	Unable	LET	CS	CS	Left eye difficulty fixating with visuoscope
		Left	+4.00-1.00X180	Unable		CS	CU	
13	4	Right	+5.00	20/200	Microtropia	½ nasal EF	½ nasal EF	Equal with both
		Left	+1.00	20/20		CS	CF	
14	4.5	Right	-5.50-0.75X003	20/40	Myopia	CS	CS	Left eye difficulty fixating with visuoscope
		Left	-4.75-1.00X032	20/40		CS	CU	
15	4.5	Right	+0.25-0.75X180	20/25	Astigmatism	CS	Unable	Unable to fixate visuoscope
		Left	+0.25-0.75X180	20/25		CS	Unable	
16	5	Right	+0.75	20/25	Microtropia	CS	CS	Easier with streak
		Left	+3.00	20/100		½ nasal EF	½ nasal EF	
17	5	Right	+3.00-1.25X180	20/30	Hyperopia	CS	CS	Equal with both
		Left	+3.25-1.50X007	20/30		CS	CS	

TABLE (continued)

PATIENT FINDINGS WITH TRADITIONAL VISUOSCOPE AND STREAK TARGETS

Patient No.	Age (y)	Eye	Refraction	Visual Acuity	Diagnosis	Streak	Visuoscope	Comments
18	5	Right	+1.00-1.50X143	20/30	Refractive amblyopia	CS	CU	Easier with streak; did not understand visuoscope at first
		Left	+0.50-2.00X016	20/30		CS	CU	
19	5.5	Right	+1.00	20/20	Anisometropia amblyopia	CS	CS	Equal with both
		Left	+2.25	20/30		CU	CU	
20	6	Right	Plano	20/20	Refractive amblyopia, EF	CS	CS	Easier with streak
		Left	+5.00-1.25X180	20/200		2^ nasal EF	2^ nasal EF	
21	6.2	Right	-1.25-0.50X180	20/20	Anisometropia	CS	CU	Easier with streak; unsteady with visuoscope
		Left	+0.75	20/20		CS	CU	
22	6.5	Right	+0.75-2.50X177	20/25	LXT	CS	CS	Easier to detect EF with visuoscope
		Left	+0.75-2.00X180	20/50		CU	2^ super EF	
23	7	Right	+4.75-1.25X003	20/40	Refractive amblyopia	UC	UC	Equal with both
		Left	+6.25-2.50X015	20/70		UC	UC	
24	7	Right	+5.00-1.00X180	20/30	Strabismic amblyopia, EF	CS	CS	Easier with visuoscope
		Left	+5.50-1.25X180	20/80		2.5^ nasal EF	2.5^ nasal EF	
25	7	Right	+0.50	20/25	LXT, amblyopia	CS	CS	Easier with streak
		Left	+1.50-1.00X180	20/30		CU	CU	
26	7	Right	+1.00-2.00X010	20/25	Refractive amblyopia	CS	CU	Difficulty keeping eye steady with visuoscope
		Left	+1.25-2.75X177	20/30		CS	CU	
27	7	Right	+4.00-2.50X178	20/40	Accommodative ET	CS	CS	Equal with both
		Left	+6.50-1.50X174	20/40		CS	CS	
28	7	Right	+0.25-0.25X180	20/20	Emmetropia	CS	CU	Left eye easier with streak; right eye equal ease
		Left	+0.25-0.25X180	20/20		CS	CU	
29	7	Right	+1.50-3.75X005	20/30	Refractive amblyopia, EF	1^ tem EF	1^ tem EF	Equal with both
		Left	+1.50-3.75X180	20/20-		CU	CU	
30	7	Right	+5.50-3.00X180	20/60	EF, RET, amblyopia	3^ nasal EF	3^ nasal EF	Easier to quantify with visuoscope
		Left	+5.50-3.00X180	20/25		CS	CS	
31	7.1	Right	-1.25-0.25X103	20/20	Myopia	CS	CS	Fixation easier; moved fixation vertically with streak
		Left	-1.00	20/20		CS	CS	

TABLE (continued)

PATIENT FINDINGS WITH TRADITIONAL VISUOSCOPE AND STREAK TARGETS

Patient No.	Age (y)	Eye	Refraction	Visual Acuity	Diagnosis	Streak	Visuoscope	Comments
32	8	Right	-1.00-2.00X180	20/30	Refractive amblyopia, AXT	CS	CS	Equal with both
		Left	-1.00-2.25X180	20/30		CS	CS	
33	8	Right	+0.75-5.00X005	20/30	Refractive amblyopia	CS	CU	Easier with streak
		Left	+0.75-2.25X180	20/20		CS	CS	
34	8	Right	+1.50-3.00X180	20/30	Amblyopia aniso-metropia, LET	CS	Unable	Non-English speaking; did not understand visuoscope
		Left	+3.00-1.50X180	20/60		CU	Unable	
35	9	Right	-0.25	20/25	DE alt XT	CS	CU	Easier with streak
		Left	-0.50	20/25		CS	CS	
36	10	Right	+0.50-0.25X009	20/20	Emmetropia	CS	CU	Non-English speaking
		Left	+0.50-0.25X173	20/20		CS	CS	
37	11	Right	-4.25-1.00X090	20/30	Microtropia, anisometropia amblyopia, EF	1^ super EF	1^ super EF	Equal with both
		Left	-1.00	20/20		CS	CS	
38	11	Right	+0.50-0.25X090	20/20	Alt ET, anisometropia	CS	CS	Equal with both
		Left	-1.75-0.50X094	20/20		CS	CS	
39	11	Right	-1.75	20/20	Myopia	CS	CS	Easier with streak; confusion with visuoscope
		Left	-1.50-0.75X086	20/20		CS	CS	
40	11.5	Right	-6.25-0.50X174	20/20-	Myopia	CS	CS	Easier with streak; confusion with visuoscope
		Left	-5.50-0.25X177	20/20-		CS	CS	
41	12	Right	+4.00-0.50X120	20/70	Anisometropia amblyopia, EF	2^ nasal EF	1^ nasal EF	Easier with streak
		Left	+0.75	20/20		CS	CF	
42	13	Right	-3.25-0.75X178	20/20	Myopia	CS	CS	Equal with both
		Left	-3.25-0.75X162	20/20-		CS	CS	
43	13	Right	-2.00-0.25X180	20/20	Myopia	CU	CS	Easier with visuoscope
		Left	-1.75-0.50X180	20/20		CU	CS	
44	13	Right	-1.75	20/20	Myopia	CS	CS	Equal with both
		Left	-2.00	20/20		CS	CS	
45	15	Right	-1.50-2.75X176	20/20	LET, EF	CS	CS	EF detected with both
		Left	+0.50-3.25X011	20/30	Anisometropia amblyopia	2^ inf	2^ inf	

TABLE (continued)

Patient Findings With Traditional Visuoscope and Streak Targets

Patient No.	Age (y)	Eye	Refraction	Visual Acuity	Diagnosis	Streak	Visuoscope	Comments
46	17	Right	+0.75	20/20	LET, EF	CS	CS	Easier to determine magnitude with visuoscope
		Left	+3.50	20/80	Refractive amblyopia	2-3^ nasal EF	2^ nasal EF	
47	22	Right	-3.50+0.50X85	20/20	LET, Lhypo, EF	CS	CS	Equal with both
		Left	-3.75+0.50X125	20/100		1^ inf & nasal EF	1^ inf & nasal EF	

CU = central unsteady fixation; Alt ET = alternating esotropia; CS = central steady fixation; LET = left esotropia; XT s/p = status postsurgery for exotropia; EF = eccentric fixation; CF = central fixation; ^ = prism diopter; LXT = left exotropia; super = superior; ET = esotropia; tem = temporal; RET = right esotropia; AXT = alternating exotropia; DE alt XT = intermittent exotropia of the divergence excess type; inf = inferior; Lhypo = left hypotropia.

opia can be improved with the use of a random dot stereogram, the 4-PD test of Irvine, or a vertical 15-D prism to induce a temporary strabismus (nonamblyopes alternate while amblyopes usually do not).

Random dot stereogram testing is sensitive but not specific for all constant strabismics including microtropes, ie, they will not appreciate a random dot stereogram.[13] It should be noted that many anisometropic amblyopes without eccentric fixation will pass a random dot stereogram.[13] Another disadvantage of the random dot stereogram is that it requires a relatively cooperative patient. The 4-PD test for suppression will be positive for amblyopes who have at least a 4-PD suppression zone.[13] It should be noted that not only amblyopes will demonstrate a positive 4-PD test, but any patient with a suppression zone greater than 4 PD will fail the test. Thus, the 4-PD test is not specific for amblyopia and requires a cooperative patient. The 15-D vertical test seems to be clinically sensitive and specific for amblyopia; however, no study has been performed to determine its specificity and sensitivity. Microtropia is diagnosed with accurate (negative) unilateral cover test and a measurement of monocular fixation status.

Visuoscopy performed to detect amblyopia in the nonverbal child with microtropia may result in earlier diagnosis and treatment of amblyopia. In our experience, treatment of amblyopia related to microtropia is responsive to occlusion, atropine therapy, or both when detected at a young age. The findings of this study demonstrate traditional visuoscopy is difficult to perform in young children. Our streak visuoscopy method significantly improved testability for eccentric fixation in children younger than 3 years.

For every child in whom streak visuoscopy could be performed, standard visuoscopy also could be performed; however, the converse was not true. Every child who demonstrated eccentric fixation by traditional visuoscopy also demonstrated eccentric fixation by the streak method. Also, every child who demonstrated central fixation with the traditional method demonstrated central fixation with the streak method. By adding streak visuoscopy to the examination of young children, it is our belief that earlier detection of amblyopia in microtropes can be attained. The technique is rapid and does not require additional equipment. It can be performed

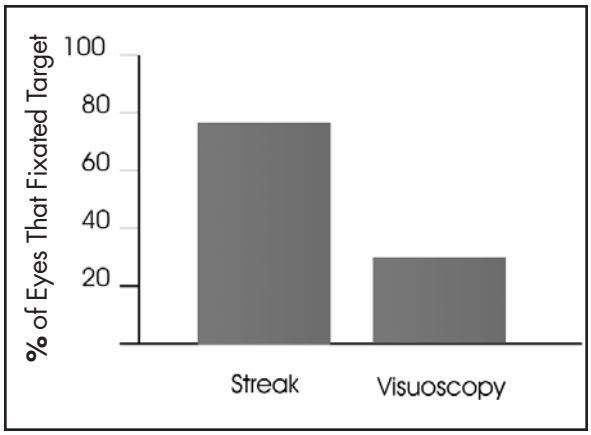

Figure 3. Bar graph comparing use of streak and traditional visuoscope targets to detect fixation in children younger than 3 years.

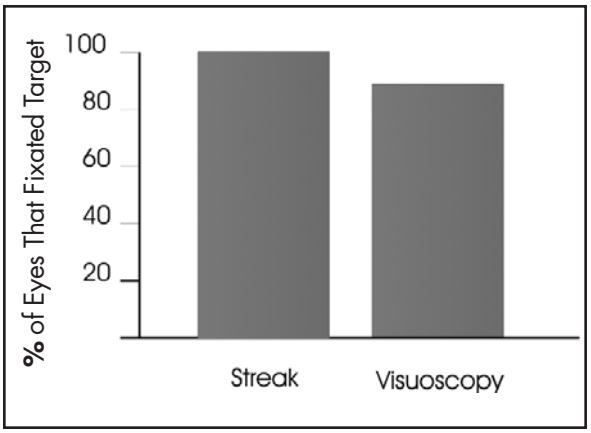

Figure 4. Bar graph comparing use of streak and traditional visuoscope targets to detect fixation in children older than 3 years.

in both eyes, thereby using the nonamblyopic eye as a control. We believe earlier detection may help eliminate or decrease the prevalence of permanent amblyopic loss of vision.

Finally, by having a simple method to monitor fixation, it is possible to indirectly monitor treatment progress, as eccentric fixation is always associated with reduced visual acuity. Thus, one may presume that if eccentric fixation is found with visuoscopy, then visual acuity must be less than 20/20. With occlusion or atropine therapy, one would expect both visual acuity and fixation to improve concurrently, ie, fixation would become more central. Therefore, improvement in fixation pattern by treatment is an indirect measurement of improvement of visual acuity.

Conclusions

This study demonstrates the streak of a direct ophthalmoscope can determine the presence of eccentric fixation in most children younger than 3 years. Only 30% of the children younger than 3 years were able to perform visuoscopy using a traditional visuoscope target. We found the traditional visuoscope target is not an appropriate target for nonverbal younger children because they tend to look around the target instead of fixating on its center. The streak target provides a reflex stimulus, whereby most children automatically fixate it. Patients older than 3 years easily fixated the center of either target. Therefore, for patients older than 3 years, either technique can be readily used to determine eccentric fixation. Even after age 3 years, nonverbal or non-English speaking patients perform more reliably with the streak method in the assessment of monocular fixation. Assessment of eccentric fixation in the young nonverbal child may be helpful in identifying amblyopia in children with microtropia prior to measurement of visual acuity. This is important because the earlier amblyopia is diagnosed, the better the chance of improving visual acuity.

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