European Journal of Ophthalmology / Vol. 10 no. 1, 2000 / pp. 4-10

Distance alternate-letter suppression test for objective assessment of sensorial status in intermittent exotropia

C. YILDIRIM[1], H.I. ALTINSOY[2]

[1] Department of Ophthalmology, Pamukkale University School of Medicine, Denizli
[2] Department of Ophthalmology, Gülhane Military Medical Academy Eye Clinic, Ankara - Turkey

PURPOSE. *To investigate the value of distance alternate-letter suppression testing in the objective assessment of fusional control of intermittent exotropia.*
METHODS. *A total of 71 consecutive patients with intermittent exotropia (study group) and 112 normal subjects (control group) underwent a series of measurements including distance alternate-letter suppression testing, Worth 4 Dot test at distance and near, and distance and near stereo acuity tests to see whether sensorial behavior differed in the study and control groups. The distance alternate-letter suppression test and distance stereo acuity tests were performed using the Mentor B-VAT II-SG Video Acuity Tester and Binocular Vision Testing System. The TNO test was used to measure near stereo acuity.*
RESULTS. *Seventeen patients with intermittent exotropia (24%) presented suppression with the distance alternate-letter suppression test, but none of the normal subjects ($p<0.001$, χ^2 test). Only, three patients (4%) showed suppression on the Worth 4 Dot test at distance, and all had fusion on the Worth 4 Dot test near. Patients with intermittent exotropia had significantly diminished distance stereo acuity compared to normal subjects ($p<0.001$). Normal subiects and patients had good near stereo acuity ($p>0.05$). Patients with intermittent exotropia who had fusion with the distance alternate-letter suppression test had significantly better distance stereo acuity than patients who had suppression ($p<0.001$).*
CONCLUSIONS. *Distance alternate-letter suppression testing and distance stereo acuity tests may be useful as objective measures for assessing sensory loss in patients with intermittent exotropia. (Eur J Ophthalmol 2000; 10: 4-10)*

KEY WORDS: *Distance alternate-letter suppression testing, Distance stereo acuity, Intermittent exotropia*

Accepted: April 19, 1999

INTRODUCTION

Clinicians have to decide how to assess fusional control of exodeviation in intermittent exotropia in order to plan the best timing of any therapeutic intervention. Objective techniques used for assessing the sensorial status of patients with intermittent exotropia include measuring the deviation and near stereo acuity (1-4). Patients with large deviations are likely to have poor control because control of large deviations requires large fusional vergences. However, some patients with relatively small deviations may have poor control too (2, 5). Several studies have measured near stereo acuity in intermittent exotropia and most of

1120-6721/004-07$03.50/0

them report that almost all patients had excellent near stereo acuity (4-7). Thus, the size of the deviation or near stereo acuity threshold does not correlate well with fusional control in patients with intermittent exotropia.

As distance control of fixation in intermittent exotropia is often the first to deteriorate, assessing the patient's binocular function at distance may provide an early measure of the degree of control (5, 8, 9). Stathacopoulos et al (8) found that patients with intermittent exotropia had significantly worse distance stereo acuity than normal subjects, and concluded that diminished distance stereopsis seems to be an objective measure of poor control of the exotropic deviation. Guyton (10) anecdotally mentioned that some patients with intermittent exotropia had a monocular suppression scotoma in the binocular visual fleld on the distance vectographic alternate-letter test, while still retaining distance stereo acuity on the vectographic contour circles test. He concluded that distance alternate-letter suppression testing might even be a better indicator of early loss of fusional function in intermittent exotropia.

To our knowledge, no studies have investigated the utility of the distance alternate-letter suppression test in intermittent exotropia. This study presents a series of intermittent exotropia cases examined to establish whether distance alternate-letter suppression testing was an objective method for assessing control of exodeviation.

METHODS

Study group

Consecutive patients with intermittent exotropia followed at the Gulhane Military Medical Academy Eye Clinic between 1995 and 1997 were included in this prospective, institutional study subject to the following exclusion criteria: amblyopia (defined as more than 2 lines of best-corrected visual acuity difference between the eyes), more than 2 diopters of anisometropia, strabismus surgery before initial presentation. Patients who were not cooperative enough to permit accurate measurements with the sensorial tests and patients with other ocular diseases were also excluded.

Control group

A group of 112 normal people from the kindergarten classes (45 subjects) and medical school (67 subjects) at the Gulhane Military Medical Academy were enrolled to obtain the population reference data for the sensory tests. Normal subjects were required to have at least 20/25 best-corrected vision for each eye with not more than 1 diopter of anisometropia or 5 prism diopters (Δ) of phoria. All controls had the cognitive ability to perform the sensory tests and were measured on the same equipment with the same protocols, at the same institution.

Informed consent was obtained from all adult patients and normal subjects or legal guardians of minors.

Motor evaluation

We considered patients to have intermittent exotropia if their exodeviation was intermittently manifest either near or at distance when examined at the office. Measurements of intermittent exodeviations were obtained in all patients at distance (6 m) and near (40 cm) in fixation on accommodative targets using the alternate prism cover test, with spectacle corrections when required. The deviation was remeasured at near fixation after occlusion of an eye for an hour, to differentiate simulated from true divergence excess intermittent exotropia (11).

Sensory evaluation

All the tests were done under normal room lighting and there was no time limit for responding.

Fusion tests

Distance alternate letter suppression test: this was done using the commercially available Mentor B-VAT II-SG Video Acuity Tester and Binocular Vision Testing System. This unit consists of a video screen, binocular glasses, a high-frequency microprocessor and a computerized hand control device. The subject wears the glasses connected to the microprocessor module through a driver box. The binocular glasses are constructed with separate apertures for each eye. Each aperture has a liquid crystal shutter that can trans-

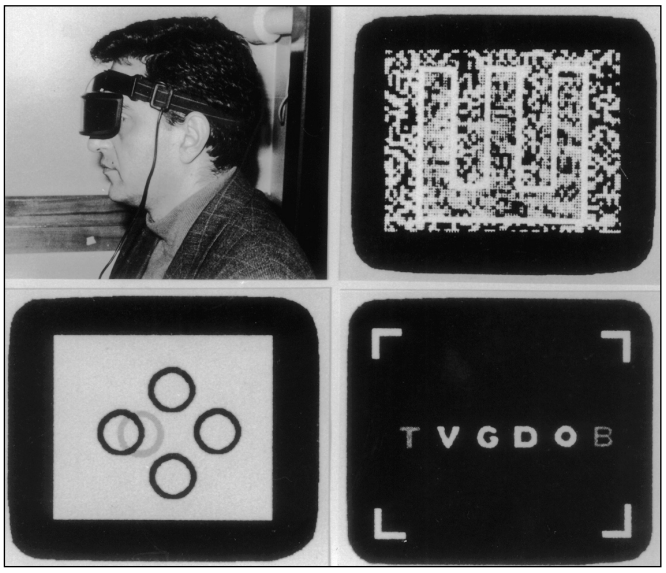

Fig. 1 - Top left, *patient wearing liquid crystal binocular glasses for vision tests on the Mentor B-VAT II-SG Binocular Vision Testing System.* Top right, *random dot E pattern to test distance random dot (global) stereo acuity (DVRDE test).* Bottom left, *circles to test distance contour stereo acuity (DVC test).* Bottom right, *A single line of 20/60 Snellen letters on the video screen to test suppression (distance alternate-letter suppression test). The test symbol at the left end of the line "T" could only be seen with the left eye, and the test symbol at the right end of the line "B" could only be seen with the right eye. The four symbols between the left and right end of the line (V, G, D, O) could be seen with both eyes.*

mit or block out light. The shutter signal (OPEN or CLOSED) sent by the microprocessor is synchronized with the presentation of two different images on the video screen, so that either image can be presented independently, to each eye. This system runs at 60 video frames per second. Although the flicker rate (image frame + blank frame) is 60 Hz for each eye, the images alternate between the eyes at the edge of the 'binocular alternating frequency fusion' (30 Hz), and the observer perceives the images as continuous. The system can be calibrated for use at viewing distances of 3 and 6 m (12).

In the test, subjects viewed the monitor at 6 m, with the binocular glasses worn over the best refractive corrections (Fig. 1, top left). A single line of test symbols (Snellen letters, Landolt Rings, Tumbling E's or "H O T V" symbols) was displayed on the video screen. The observer can change the size of the test symbol to the desired acuity level, using the computerized hand control device. We used a 20/60 acuity level of symbol size for all subjects, with six symbols displayed on the monitor (Fig. 1, bottom right). The subjects were asked to read the symbols on the screen, the test symbol on the left end of the line could only be seen with the left eye, and the test symbol on the right end of the line could only be seen with the right eye. The four symbols between the left and right ends could be seen with both eyes. Subjects who had a suppression scotoma missed the symbol at the beginning or end of a line, depending on the suppressed eye. Subjects without any suppression scotoma could see all the symbols. The whole line of 20/60 test symbols subtended a visual angle of 1.4° at the 6 m viewing distance.

Worth 4 Dot test: this was done near (40 cm) and at distance (6 m). The subjects viewed a Worth 4 Dot flashlight near and a Worth 4 Dot light box at distance, wearing the red and green glasses. The Worth 4 dots subtended a visual angle of 6° near and 1.5° at distance.

Stereopsis tests

Distance stereopsis: this was measured using the Mentor B-VAT II-SG Video Acuity Tester and Binocular Vision Testing System at 6-m viewing distance.

The two stereo acuity tests available on this system in are the Distance Vision Random Dot E stereopsis test (DVRDE) and the Distance Vision Contour stereopsis test (DVC). The test methods have been described in detail elsewhere (7,12).

Initially, a 6/96 (20/320) tumbling E was presented as the 'entry screen' on the video monitor. If the subject was able to appreciate and respond correctly to the orientation of the E, the tests were started. Distance random dot stereo acuity was tested using a tumbling E presented randomly in one of three orientations, either up, down, or horizontally to the right (Fig. 1, top right). The subject was asked to state the orientation of the letter popping out of the screen. The stereo disparity of the letter E was decreased progressively from 240 to 180, 120, 60, 30, and 15 seconds of arc (") until its direction could not be correctly identified. The last correct response was recorded as the distance random dot stereo acuity threshold.

The same method was used to determine the distance contour stereopsis threshold. In this test, the

patient initially viewed four circles at 240" and was asked to determine "which of the four circles (top, bottom, left, or right) popped out of the screen" (Fig. 1, bottom left). For statistical purposes patients with no distance stereo acuity on the tests were recorded as having 400".

Near stereopsis: this was tested with the TNO random dot test. The test stereogram was held up 40 cm from the subject during the test. The subjects wore polaroid red and green glasses and were told to point where the piece was missing in each segment of the plates.

Statistical methods

Student's t and Mann Whitney tests were used to compare two group means. Chi-square or Fisher's exact tests were also used to test the association between discrete variables. Any differences in which the p value was below 0.05 were regarded as statistically significant.

RESULTS

This series gives the measurements of 71 patients with intermittent exotropia, aged between 5 and 57 years; 37 were female and 34 were male. The majority (53/71; 75%) were younger than 20 years. The mean exodeviation was 23 ± 9 Δ (range 10-51 Δ) at distance and 16 ± 10 Δ (range 0-45 Δ) near. Using Burian's classification of intermittent exotropia (13), we found 14 patients with divergence excess intermittent exotropia, 30 with simulated divergence excess intermittent exotropia and 27 with basic intermittent exotropia.

Fusion tests

Table I shows the results of the distance alternate-letter suppression test and Worth 4 Dot test for patients with intermittent exotropia and normal controls. Of the 71 patients 17 (24%) had monocular suppression under binocular viewing conditions with the distance alternate-letter suppression test compared to none of the 112 controls. This difference was significant ($p<0.001$, χ^2 test). Only three patients (4%) with intermittent exotropia had suppression on the Worth 4 Dot test at distance. The three also had suppression in the distance alternate-letter suppression test. The intermittent exotropia patients with suppression in the distance alterante-letter suppression test (24%) were significantly more than those with suppression in the Worth 4 Dot test at distance (4%) ($p<0.001$, χ^2 test). None of the patients had suppression on the Worth 4 Dot test near. All normal controls showed fusion with the Worth 4 Dot test both at distance and near.

There was no significant difference between the patients with intermittent exotropia who had suppression and those who had fusion in the distance alternate-letter suppression test, in relation to age, near deviation or distance deviation ($p>0.05$).

Stereopsis tests

The stereo acuity data for the study and control groups are shown in Table II. Regardless of their oculomotor status, patients with intermittent exotropia had significantly less distance stereo acuity than normal subjects in both the DVC and DVRDE tests ($p<0.001$). No

TABLE I - RESULTS OF THE DISTANCE ALTERNATE-LETTER SUPPRESSION TEST AND WORTH 4 DOT TEST FOR PATIENTS WITH INTERMITTENT EXOTROPIA (Study Group) AND NORMAL SUBJECTS (Control Group). The number and percentage of subjects with fusion or suppression in each test are given

	Distance alternate letter suppression test		**Distance Worth 4 Dot test**		**Near Worth 4 Dot test**	
Group	Fusion	Suppression	Fusion	Suppression	Fusion	Suppression
Study (n = 71)	54 (76%)	17 (24%)	68 (96%)	3 (4%)	71 (100%)	None (0%)
Control (n = 112)	112 (100%)	None (0%)	112 (100%)	None (0%)	112 (100%)	None (0%)

significant near stereo acuity differences were found for patients with intermittent exotropia and controls.

There were clinically important differences between the near and distance stereo acuity thresholds for many patients with intermittent exotropia. Seventeen (24%) patients could not appreciate the stereoscopic view of the DVC test at the 240" threshold level, and 20 (28%) could not appreciate stereopsis in the DVRDE test. All patients unable to appreciate stereopsis at distance with the DVC and DVRDE tests demonstrated stereopsis near in the TNO test. Eight patients with intermittent exotropia (11.3%) achieved near stereopsis worse than 60", the median of the study and control groups. These eight patients with subnormal near stereo acuity still had better stereo acuity near than at distance.

Distance alternate-letter suppression and stereopsis tests

Patients with intermittent exotropia who had fusion in the distance alternate-letter suppression test had significantly better mean distance stereo acuity thresholds than those who had suppression ($p<0.001$). Near stereo acuity performance was comparable in these two groups. Figure 2 shows the median stereo acuity thresholds for patients with intermittent exotropia based on the subsets of patients with fusion or suppression in the distance alternate-letter suppression test. For patients with suppression, the median stereo acuity thresholds in the TNO, DVC, DVRDE tests were 60", 400", and 400", respectively; for the patients with fusion, they were 60", 120", and 180". Of

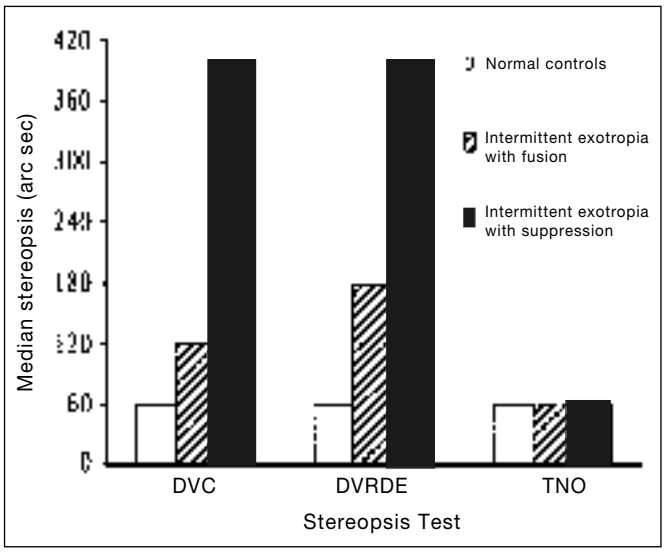

Fig. 2 - *Median distance stereopsis values for normal controls, intermittent exotropia patients with fusion and intermittent exotropia patients with suppression in the distance alternate-letter suppression test. DVC = Distance Vision Contour stereo acuity test. DVRDE = Distance Vision Random Dot E stereo acuity test. For statistical purposes patients with no distance stereo acuity in the tests were recorded as having 400 arc seconds.*

the 17 patients with intermittent exotropia who showed suppression in the distance alternate-letter suppression test, only two (12%) had 120" or better distance stereo acuity in the DVC test; 16 (94%) achieved 180" or worse in the DVRDE test. Conversely, of the 54 patients with fusion in the distance alternate-letter suppression test, 33 (61%) achieved 120" or better in the DVC test and 21 (39%) in the DVRDE test.

Six patients with intermittent exotropia had suppression in the distance alternate-letter suppression test, but

TABLE II - NEAR AND DISTANCE STEREO ACUITY DATA FOR NORMAL CONTROLS AND PATIENTS WITH INTERMITTENT EXOTROPIA. DVC = Distance Vision Contour stereo acuity test. DVRDE = Distance Vision Random Dot E stereo acuity test

	Normal controls			**Patients with intermittent exotropia**		
Test	Median (arc sec)	Mean (arc sec)	Range* (arc sec)	Median (arc sec)	Mean (arc sec)	Range* (arc sec)
TNO	60	63	15-240	60	73	30-480
DVC	60	50	15-180	120	183	15-400
DVRDE	60	95	15-400	180	226	30-400

* For statistical purposes patients with no distance stereo acuity in the tests were recorded as having 400 arc second

retained some distance stereo acuity. However, another six patients had fusion in the distance alternate-letter suppression test, but no distance stereopsis in the DVC and DVRDE tests.

DISCUSSION

This study suggests that the distance alternate-letter suppression test may provide objective information for assessing sensorial status in patients with intermittent exotropia. First, we found that 24% of patients with intermittent exotropia showed suppression in this test, contrary to normal subjects none of whom presented suppression. Second, patients with intermittent exotropia who presented suppression in the distance alternate-letter suppression test had significantly lower distance stereo acuity than patients who had fusion. Diminished distance stereo acuity is an indicator of deterioration in control of the exotropic deviation (5, 8) so presumably although only a longitudinal study can tell for certain, suppression in the distance alternate-letter suppression test indicates some loss of sensorial function caused by progression of the intermittent exotropia.

The distance alternate-letter suppression test-available on the Mentor B VAT II-SG Binocular Vision Testing System and the Worth 4 Dot test subtend a visual angle of approximately 1.5° at the 6-m viewing distance. Since the foveal region occupies about 1.5 mm or 5° of arc on the retina in the human being (14), any suppression scotoma identified by both these tests under binocular viewing conditions was considered as foveal (central) suppression. Those with no suppression scotoma were considered to have bifoveal fusion. However, a significantly higher percentage of patients with intermittent exotropia presented suppression in the distance alternate-letter suppression test than in the distance Worth 4 Dot test. Some of this difference might be due to the difference between the dissociating power of the two tests. New instrument design and technical differences in generating the computer images for the Mentor B-VAT II-SG Binocular Vision Testing System are the other variables that may also account for this difference.

We did all the sensory tests with the room lights on. Thus patients could see the room environment, which provided additional binocular peripheral fusion cues to help maintain alignment while the binocular shutter glasses or the red and green glasses were on. Moreover, because the alternation rate for the liquid shutter glasses is higher than the brain's flicker rate for fusion (7,9), the distance alternate-letter suppression test should not be extremely dissociative. However, it is still possible that the distance alternate-letter suppression test was more dissociative than the distance Worth 4 Dot test. Nevertheless, absence of bifoveal fusion with the distance alternate-letter suppression test under binocular viewing conditions indicates how easily fusion might be interrupted in a patient with intermittent exotropia.

Our findings are consistent with those of other reports that patients with intermittent exotropia had significantly diminished distance stereo acuity compared to normal subjects, whereas near stereo acuity performance was similar (7-9). Rosenbaum and Stathacopoulos (5) stated that distance stereopsis is a measure of central fusion and may be an early measure of the degree of control in intermittent exotropia. However, it is not understood why distance stereo acuity is reduced or absent and near stereo acuity is excellent in patients with intermittent exotropia. Parks (15) measured distance stereopsis using the Polaroid vectographic slide in normal subjects and in patients with monofixation syndrome and foveal suppression. Distance stereo acuity thresholds better than 120" were obtained only by patients not having foveal suppression, whereas distance stereo acuity thresholds worse than 120" were only seen in patients with foveal suppression.

We found that patients with intermittent exotropia who had suppression in the distance alternate-letter suppression test had worse distance stereo acuity than patients with fusion. A small manifest deviation with foveal (central) suppression in some intermittent exotropia cases, when the large tropic deviation is controlled, has also been suggested (16). These findings support the idea that when a patient with intermittent exotropia who had tentative control wore the binocular shutter glasses, a microdeviation and foveal suppression become manifest, resulting in reduced distance stereo acuity, similar to that in patients with monofixation syndrome (8, 9, 15).

Epstein and Tredici (17) showed that some microexostrabismic patients had a monocular suppression scotoma in the binocular visual field in the dis-

tance vectographic alternate-letter suppression test, while still retaining distance stereo acuity in the vectographic contour circles test. They reported that central suppression occured before significant loss of distance stereo acuity in intermittent exotropia. According to our results one cannot predict whether the distance alternate-letter suppression test or distance stereo acuity test is more sensitive for assessing early sensory loss in intermittent exotropia, for two reasons. First, the study design was cross sectional rather than longitudinal. Second, in this series, six patients with intermittent exotropia had suppression (foveal) in the distance alternate letter suppression test but still had distance stereo acuity. However, there another six patients presented fusion (bifoveal) with the distance alternate-letter suppression test but could not achieve any measurable distance stereo acuity. In conclusion, we recommend using the distance alternate-letter suppression test and measuring distance stereo acuity for objective assessment of the control of exodeviation in patients with intermittent exotropia.

ACKNOWLEDGEMENTS

The study was conducted at: Gülhane Military Medical Academy Eye Clinic, Ankara, Turkey

Reprint requests to:
Cem Yildirim, MD
P.K. 66, Denizli
20003 Turkey
e-mail: yildirimc@hotmail.com

REFERENCES

1. Parks MM, Mitchell PR. Concomitant exodeviations. In: Duane TD, Jaeger EA, eds. Clinical Ophthalmology, vol. 1. Philadelphia, PA: Harper & Row, 1986; 13: 1-11.
2. Cooper J, Medow N. Major review: Intermittent exotropia. Basic and divergence excess type. Binocular Vision Eye Muscle Surg Q 1993; 8: 185-216.
3. von Noorden GK. Binocular vision and ocular motility, 4th ed. St. Louis: CV Mosby, 1990; 323-50.
4. Richard JM, Parks MM. Intermittent exotropia: surgical results in different age groups. Ophthalmology 1983; 90: 1172-7.
5. Rosenbaum AL, Stathacopoulos RA. Subjective and objective criteria for recommending surgery in intermittent exotropia. Am Orthop J 1992; 42: 46-51.
6. Baker JD, Davies GT. Monofixational intermittent exotropia. Arch Ophthalmol 1979; 97: 93-5.
7. Zanoni D, Rosenbaum AL. A new method for evaluating distance stereo acuity. J Pediatr Ophthalmol Strabismus 1991; 28: 255-60.
8. Stathacopoulos RA, Rosenbaum AL, Zanoni D, et al. Distance stereoacuity: assessing control in intermittent exotropia. Ophthalmology 1993; 100: 495-500.
9. Rutstein RP, Fuhr P, Schaafsma D. Distance steropsis in orthophores, heterophores, and intermittent strabismics. Optom Vis Sci 1994; 71: 415-21.
10. Guyton DL. Discussion of: Distance stereo acuity improvement in intermittent exotropic patients following strabismus surgery. J Pediatr Ophthalmol Strabismus 1995; 32: 358.
11. Kushner BJ. Exotropic deviations. A functional classification and approach to treatment. Am Orthoptic J 1988; 38: 81-93.
12. Instruction manual. B-VAT™ II-SG Video Acuity Tester. Norwell, Mass.: Mentor O&O, 1987.
13. Burian HM. Exodeviations: Their classification, diagnosis and treatment. Am J Ophthalmol 1966; 62: 1161-6.
14. Cohen AI. The retina. In: Moses RA, Hart WM, eds. Adler's physiology of the eye, 8th ed. St. Louis, MO: CV Mosby, 1987; 458-90.
15. Parks MM. The monofixation syndrome. Trans Am Ophthalmol Soc 1969; 67: 609-57.
16. Forrer HT. Retinal correspondence in intermittent exotropia. In: Moore S, ed. Orthoptics. Past, present, future. New York, NY: Stratton Inter-Continental Medical Books Corp, 1976; 547-9.
17. Epstein DL, Tredici TJ. Microtropia (monofixation syndrome) in flying personnel. Am J Ophthalmol 1973; 76: 833-41.