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CLINICAL INVESTIGATIONS

Clinical and Sensorial Characteristics of Microtropia

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Purpose: To investigate the clinical characteristics and sensory mechanism of microtropia.

Methods: Twenty patients with primary microtropia were studied. The patients were evaluated by the visuscope, Irvine prism test, Bagolini striated glasses test, Worth 4-dot test (W4D), TNO, and stereo-fly plate of the Titmus test.

Results: The patients who had positive cover test and eccentric fixation showed wandering eccentric fixation. The Irvine prism test was positive in all the patients by using prisms of different strengths and positions. All the patients had abnormal fusion at near. At distance, 15 patients had abnormal fusion by the Bagolini glasses and 8 patients had abnormal fusion by the Worth test. Ten patients had gross stereopsis and the remaining 10 had no measurable stereopsis.

Conclusions: The type of microtropia with eccentric fixation without identity is mainly due to the wandering eccentric fixation. All patients with microtropia have abnormal fusion without fixation point scotoma because positive prism test response does not change to normal by using prisms of different strengths and positions. Differences in fusion results are mainly due to the weakness of abnormal fusion rather than fixation point scotoma. With occlusion treatment, amblyopia can be improved, whereas binocular defects of microtropia cannot be improved. **Jpn J Ophthalmol 2002;46:52–58**

Key Words: Amblyopia, eccentric fixation with or without identity, fixation preference, microtropia.

Introduction

Microtropia is characterized by a squint angle of 8–10 prism diopters (pd) or less under binocular conditions, various degrees of amblyopia in the deviated eye, peripheral fusion and defective stereopsis.[1–3] Parks[1] used the term monofixational syndrome to describe an absence of bifoveal fusion with maintenance of normal retinal correspondence (NRC) associated with a stretched Panum area. Lang[2] introduced the terms microtropia or microstrabismus to describe a small angle heterotropia less than 5° associated with abnormal retinal correspondence (ARC). This condition may be primary, or secondary following surgical or optical treatment of a larger angle of heterotropia.[1] The primary form does not show alternation (fixed grade of fixation preference),[4] whereas the secondary form may show various grades of fixation preference. Although primary microtropia is accompanied by amblyopia as a rule, amblyopia of one eye may or may not be present in secondary microtropia.[5]

A monocular fixation pattern in the deviated eye may be central or eccentric. Three types of primary microtropia can be differentiated according to the monocular fixation pattern and cover test findings: 1. Central fixation (cover test is positive). 2. Eccentric fixation with the angle of anomaly of ARC being larger than the angle of eccentic fixation (= microtropia with eccentric fixation without identity) (cover test is positive). 3. Eccentric fixation with the

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angle of anomaly of ARC identical to the angle of eccentric fixation (= microtropia with eccentric fixation with identity) (cover test is negative). In the third form, the same retinal area is used monocularly and binocularly.[6]

The difference in responses between near and distance vision when tested by the Worth 4-dot test is considered as showing the presence of suppression scotoma and the existence of peripheral fusion in patients with microtropia.[7–9] With the Bagolini test, the presence of two stripes crossing the light with an interruption in one stripe is interpreted as the existence of ARC with fixation point scotoma in patients with microtropia.[10]

In this study, we aimed to re-evaluate the clinical characteristics of microtropia and to investigate whether or not the difference in fusion between near and distance is due to the presence of fixation point scotoma in microtropia.

Materials And Methods

Twenty patients with primary microtropia were studied. Our cases were selected consecutively from patients attending the Division of Strabismus at the Department of Ophthalmology of Hacettepe University. They ranged in age from 5 to 33 years (mean age = 15.2 years). Seven of the patients had had intermittent occlusion of the sound eye after the age of 4 years, the others had never been treated before. The cover test, the cover-uncover test, and the alternate and simultaneous prism cover test were done while fixation was maintained on an accommodative target at 1/3 and 6 meters. None of the patients had a deviation greater than 10 prism diopters (D). In the patients with negative cover test, the monocular fixation pattern of the deviated eye was quite eccentric on the visuscope tests. Thus, orthotropic anisometropic amblyopia patients were eliminated from the study. If a patient with anisometropic amblyopia had bifoveolar fixation on visuscopy and had no deviation with the cover test, this patient had orthotropic anisometropic amblyopia.

The monocular fixation pattern was tested in each patient by using a visuscope with concentric circles (Welch Allyn, Skaneateles Falls, NY, USA) while the fellow eye was occluded. The fixation preference (binocularly) was assessed as well. A cycloplegic refraction test was performed on each patient, and the uncorrected and best-corrected visual acuity of each patient was determined by using the standard Snellen chart. Anisometropia was defined as a difference in refraction of 1.00 D or greater of sphere or cylinder between the 2 eyes.

The Irvine prism test was performed by using prisms of different strengths or positions (4-D, 20 base-out, and 10-D base-down) for each patient. The prism was inserted rapidly before 1 eye while the patient fixated on a point light source or an accommodative target 30–40 cm distant. We observed only the fast fixation reflex of both eyes, and then repeated the test using the other eye. If there was only a saccadic movement of the 2 eyes, putting the prism in front of the fixing eye, in the direction of the prism apex, and if there was no movement when the prism was placed in front of the deviated eye, this patient was judged to not have bifoveolar fixation and the test result was pathological, that is positive.[11]

For Bagolini testing, the glasses with striations at 45 and 135°, respectively, were placed before the patient's eyes. The patient was then asked to fixate on a spotlight at 1/3 and 6 meters, and to draw on a piece of paper what he or she saw. The patient was also asked to pay attention to any breaks in the luminous stripes, and to remember the position of the breaks if such were present. Because none of the patients was orthotropic, the presence of ARC was noted when the patient saw one light and symmetrical stripes of light forming a cross. If a little part of one stripe was not visible, this was an indication of suppression scotoma of the deviated eye. In the suppression of 1 eye, one of the stripes was not visible.

The Worth 4-dot test was performed at 1/3 and 6 meters. The position of the filters was changed in order to reveal the possibility of different responses caused by the red-green filters. The results were the same under both conditions. The responses were recorded:

1. Suppression: patient reporting only 2 or 3 dots,
2. Fusion: patient reporting 4 dots with fusion of the bottom white dot, and
3. Diplopia: patient reporting 5 dots simultaneously.

The stereoacuity in each patient was determined with the TNO test as well as the Titmus stereo-fly plate test (retinal disparity, 3000 seconds of arc). We used only the stereo-fly plate of the Titmus test because animal and circle portions may represent artificial depth perception due to the monocular clues or visible contours of the test.[12–18] However, The TNO test is devoid of any monocular clues, and the stereoscopic figures of the test can be visible only in depth. The TNO test contains three

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screening plates (retinal disparity, 1980 seconds of arc), a suppression test and three quantitative plates (retinal disparities ranging from 480 to 15 seconds of arc).

Independent sample Student *t*-test and analysis of variance were used for statistical analysis. Statistical significance was defined as $P < .05$.

Results

The microtropic eye was the right eye in 35% of the patients and the left, in 65%. Some of the results are summarized in Table 1. Only 1 patient (case 1) had microexotropia, whereas the others had microesotropia. The alternate prism cover test measurement exceeded the simultaneous prism cover test measurement in three patients (cases 3, 7, and 19).

The cover test was always positive and stable in 4 (20%) of the patients, and the monocular fixation pattern was found to be foveolar (= central) in the deviated eye. The cover test was usually positive and variable in amplitude in 9 (45%) of the patients. On visuscopy, the monocular fixation pattern was unsteady in the extrafoveolar area of the deviated eye (wandering eccentric fixation), but was not foveolar. The cover test was negative in 7 (35%) of the patients. On visuscopy, their monocular fixation pattern was steady eccentric in the deviated eye (eccentric fixation was slightly nasal extrafoveolar in 6 microesotropic patients, and slightly temporal extrafoveolar in 1 microexotropic patient).

There was no refractive error in 7 (35%) of the patients. Seven of the 13 patients with refractive error had anisometropia. When the patients were placed into two groups according to the presence or absence of anisometropia, no difference in their best-corrected visual acuity of the microtropic eye was seen ($P = .89$). In cases of anisometropia, the eye with amblyopia and microtropia was the eye with greater refractive error, except in one patient (case 11). In this patient, the best-corrected visual acuity was 20/30 in the right eye (−1.75−1.50x180), and 20/200 in the left microtropic eye (−0.25−1.50x180). When the patients were placed into three groups according to their monocular fixation pattern (central, wandering eccentric, steady eccentric), there was no significant difference in the best-corrected visual acuity of the microtropic eye ($P = .42$).

All the patients showed fixed grade of fixation preference, although all the patients with occlusion therapy had a difference in visual acuity between the eyes of one or two Snellen lines. In 13 patients without occlusion therapy, the best-corrected visual acuity ranged from 20/200 to 20/40 in the microtropic eye.

A positive Irvine prism test response was obtained in all patients. There was no difference in the responses when prisms of different strengths and positions were used.

On conducting the Bagolini test, all the patients showed abnormal fusion (provided by ARC) at near, whereas 5 (25%) showed suppression of the deviated eye at distance. None of the patients reported a small suppression scotoma of the deviated eye.

With the W4D test, all patients indicated fusion at near, whereas 12 (60%) of these patients indicated suppression of the deviated eye at distance. Five of these 12 patients also had suppression at distance by the Bagolini test.

Ten of the patients had no demonstrable stereopsis and the remaining 10 patients demonstrated stereoacuity to some degree. One microexotropic patient had a stereoacuity of 120 seconds of arc; the remaining 9 patients had poorer levels of stereopsis. Six of the 10 stereopositive patients had abnormal fusion at distance by both the Bagolini and the W4D tests. The remaining 4 stereopositive patients had abnormal fusion at distance by the Bagolini test.

Discussion

In the first type of microtropia (microtropia with central fixation), the monocular fixation pattern of the microtropic eye is always foveolar and the cover test is always positive and stable. The second type of microtropia (microtropia with eccentric fixation without identity) has been explained as being caused by the inequality between the angle of ARC and the angle of eccentric fixation.[2,6] However, we found that it is actually due to the presence of wandering eccentric fixation. That is, the angle of ARC (under binocular conditions) and the angle of eccentric fixation (under monocular conditions) are equal, but the point of eccentric fixation changes frequently because both the angle of squint (by the simultaneous prism cover test) and the point of eccentic fixation (by the visuscope) are unsteady. The cover test is usually positive and variable in amplitude in this type. The third type of microtropia (microtropia with eccentric fixation with identity) is due to the presence of steady eccentric fixation. The cover test is always negative because the angle of ARC and the angle of eccentric fixation are equal and steady. Thirty-five percent of our patients showed steady eccentric fixation as reported by Houston et al[19] in their patients.

It has been pointed out that anisometropia, although often associated with microtropia, is not a

Table 1. Clinical Characteristics of the Patients

Patient No.	Age (years)	Cover Test	Fixation*	Best Corrected VA†	Refraction	AN‡ (SE)	BG§ Distant	W4D‖ Distant	Stereo Acuity (s of arc)
1	28	Negative	Steady E	OD 20/20 OS 20/50	Plane	–	Fusion	Fusion	120
2¶	10	Positive	F	OD 20/20 OS 20/25	OD +0.75 OS + 1.00	–	Fusion	Fusion	3000
3¶	5	Positive, variable	Wandering E	OD 20/25 OS 20/20	OD +2.00+0.50×90 OS +2.00+0.50×90	–	Fusion	Suppression	Absent
4	24	Negative	Steady E	OD 20/20 OS 20/60	Plane	–	Fusion	Suppression	Absent
5	9	Positive	Wandering E	OD 20/200 OS 20/20	Plane	–	Fusion	Fusion	3000
6	33	Negative	Steady E	OD 20/20 OS 20/20	OD +2.50+0.50×180 OS +3.50+1.50×180	1.50	Suppression	Suppression	Absent
7	11	Negative	Steady E	OD 20/20 OS 20/25	OD +0.25−0.25×10 OS +1.50−0.25×70	1.25	Fusion	Fusion	1980
8¶	12	Positive	F	OD 20/30 OS 20/20	OD +4.50+0.50×90 OS +3.50+0.50×70	1.00	Fusion	Suppression	3000
9	8	Positive, variable	Wandering E	OD 20/20 OS 20/200	OD +3.50+0.50×75 OS +4.75+1.75×85	2.00	Suppression	Suppression	Absent
10	21	Positive, variable	Wandering E	OD 20/200 OS 20/20	Plane	–	Suppression	Suppression	Absent
11	13	Positive, variable	Wandering E	OD 20/30 OS 20/200	OD −1.75−1.50×180 OS −0.25−1.50×180	1.50	Suppression	Suppression	Absent
12¶	12	Positive	F	OD 20/30 OS 20/20	OD +2.50+0.25×90 OS +4.25+0.75×70	2.00	Fusion	Fusion	3000
13	11	Positive	F	OD 20/20 OS 20/200	Plane	–	Fusion	Suppression	Absent
14¶	13	Positive, variable	Wandering E	OD 20/25 OS 20/20	OD +0.75 OS Plane	–	Fusion	Fusion	Absent
15	9	Negative	Steady E	OD 20/20 OS 20/50	OD +1.00−0.50×20 OS +1.00−0.50×60	–	Fusion	Suppression	3000
16	9	Positive, variable	Wandering E	OD 20/100 OS 20/20	Plane	–	Suppression	Suppression	Absent
17	26	Positive, variable	Wandering E	OD 20/20 OS 20/200	Plane	–	Fusion	Suppression	3000
18	30	Negative	Steady E	OD 20/20 OS 20/40	OD −1.50−0.50×120 OS −2.00−0.50×55	–	Fusion	Fusion	Absent
19¶	11	Positive, variable	Wandering E	OD 20/25 OS 20/20	OD +1.75+0.75×170 OS +2.00+0.25×175	–	Fusion	Suppression	3000
20	9	Negative	Steady E	OS 20/20 OS 20/40	OD Plane OS +1.00	1.00	Fusion	Fusion	3000

*E: eccentric, F: foveolar.
† VA: visual acuity, OD, right eye, OS, left eye.
‡ AN: anisometropia, SE; spherical equivalent.
§ BG: Bagolini glasses.
‖ W4D: Worth 4-dot.
¶ Patients with occlusion therapy.

consistent finding and that anisometropic amblyopia may occur without microtropia.[6,20] In this study, anisometropia was associated with microtropia in 35% of the patients, which is similar to the report of Lang[21] in his microtropic patients. Thirty-five percent of our patients were emmetropic, whereas the others with refractive error had hyperopia more frequently than myopia. It appears that the clinical characteristics of microtropia cover a wide spectrum. Some cases may have additional heterophoria also.

Hardman Lea et al[20] and Setayesh et al[22] reported that there was no association between the depth of amblyopia and the degree of anisometropia in microtropia; whereas Lang[2,21] pointed out that amblyopia was more marked in cases with eccentric fixation and anisometropia. In this study, the best-corrected

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visual acuity of the microtropic eye was found to be independent of the behavior of the monocular fixation pattern and of the presence of anisometropia. It appears that amblyopia in microtropic patients is simply due to the absence of bifoveolar fixation.

It is said that a positive response to the 4-D prism test indicates the presence of suppression scotoma in patients with microtropia.[3,10,19,23] If a suppression scotoma were responsible for the positive response of the Irvine prism test, by using prisms of different strengths and positions, the positive responses would change to normal, as in the report of Wright et al[24] who used the prism of 10-D base-down. However, we found that the test responses were always positive by using prisms of different strengths and positions (4-D, 20-D base-out and 10-D base-down). Hence, it can be concluded that the positive Irvine prism test response in microtropia indicates simply the absence of bifoveolar fixation rather than suppression scotoma.

All the patients showed fusion at near by the Bagolini and W4D tests, whereas 5 (25%) patients showed suppression by the Bagolini test and 12 (60%) patients showed suppression by the W4D test at distance. The absence of fusion by the distant W4D compared with the presence of fusion by the near W4D has been explained by the presence of suppression scotoma.[7–9] If this had been true, we would not have found fusion by the distant W4D in 8 (40%) of the patients, or some patients would not have seen only one of the green dots or only one or two of the red dots, according to the size of the suppression scotoma. Why do the patients with suppression scotoma always see either all of the green dots or all of the red dots? Furthermore, in the present study, the patients showed either fusion or suppression rather than suppression scotoma at distance by the Bagolini test also. The difference in fusion responses between near and distance seems to be due to the decrease in binocular rivalry at near. As an object gets nearer, its retinal images become larger, thus, binocular rivalry diminishes and fusion becomes easier.[25]

The different results between the distant Bagolini and the distant W4D tests are related to the binocular rivalry effect of W4D and to the weakness of fusion. The Bagolini glasses do not alter or dissociate the real sensorial state of the patient; on the other hand, the W4D is more a dissociating test and binocular rivalry is provoked by the red and green glasses (color rivalry). Therefore, the Bagolini test reveals fusion in natural seeing, while the W4D informs us about the strength of this fusion. Abnormal fusion formed by ARC is weaker than normal fusion formed by NRC. If abnormal fusion does not withstand binocular rivalry, the patient reacts with suppression, or rarely, diplopia.[26,27]

None of the patients perceived a suppression scotoma of the deviated eye with the Bagolini test. Indeed, the image falls on an extrafoveolar point of the deviated eye (Figure 1) and ARC occurs in the binocular status. ARC is the main antidiplopic mechanism in microtropia and there is no need for extra suppression at a fixation point.[5,25] Furthermore, as pointed out by Helveston,[28] the concept of fixation point scotoma makes no sense because visual resolution potential is high at the fixation point. As a suppression scotoma does not exist in microtropia, using the term "peripheral fusion" may be misleading. It would be reasonable to use the term "nonbifoveolar" or "abnormal fusion" for these patients.

None of our patients achieved a minimum stereoacuity of 60 seconds of arc which is accepted as the normal value of stereopsis. Fifty percent of the patients had a gross degree of stereopsis. Lang[29] could not demonstrate any measurable stereoacuity in any of his patients by using random dot stereotests. In this study, only 2 of our patients were able to demonstrate stereopsis by the TNO test. One case (case 1) had microexotropia with stereoacuity of 120 seconds of arc; the other (case 7) had microesotropia with stereoacuity of 1980 seconds of arc. The fact that the microexotropic patient had a finer stereoacuity than the others may be due to the difference between temporal and nasal retina. Eight patients were able to attain only 3000 seconds of arc stereoacuity with the stereo-fly plate of the Titmus test. The remaining

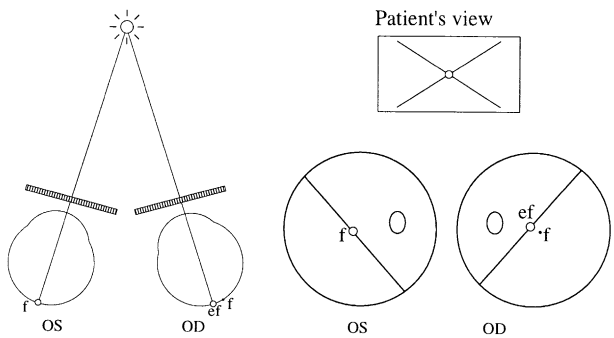

Figure 1. Results of Bagolini test in patient with microesotropia having abnormal retinal correspondence in right eye. Patient sees a cross without central interruption. This is due to fact that light is fixated with fovea in left eye (OS) and extrafoveal point of right eye (OD). Ef: extrafovea, f: fovea. From Tomaç.[25]

50% of the patients demonstrated no measurable stereoacuity; however, they had fusion.

One of our previous studies about anisometropic amblyopia,[30] together with this study, has made us suggest that anisometropic amblyopia with bifoveolar fixation occupies an intermediate state between normal and microtropia because 76% of the patients with anisometropic amblyopia had some degree of stereopsis, finer (mean = 634.7 seconds of arc, and median = 240 seconds of arc by the TNO test) than those with microtropia. If there were a deviation of 10 pd or less, only gross stereopsis would be a possible diagnosis and half of the patients would have had no measurable stereopsis. Also, in all patients with anisometropic amblyopia and orthotropia, the Irvine prism test response was negative in the amblyopic eye, although that eye was slower in responding than the other eye. It seems that the presence of NRC, even if it is weak, causes a higher grade stereoacuity in nonstrabismic anisometropic amblyopia patients; whereas ARC causes a lower grade stereoacuity in microtropic patients.

Parks[1] believed that microtropic patients have an inherent inability or loss of ability for bifoveolar fixation, and Lang[21] stated that there is a familial preponderance for ARC. Cantolino and von Noorden[31] also concluded that microtropia is the result of multiple and independently inherited binocular vision anomalies. We have not yet investigated family members in this study; therefore, we have no evidence regarding these theories. However; we believe that the initiating problem is a minor misalignment of the visual axes, and that the sensory adaptations, such as extrafoveolar fixation and ARC follow. Amblyopia is also the result of microtropia rather than the cause, because the image falls on an extrafoveolar point of the deviated eye having lower resolution power than the foveola. The inhibition of NRC and the occurrence of ARC create amblyopia.

In children up to 9 years of age, the treatment of microtropia includes occlusion of the sound eye for amblyopia and optical correction when needed. Seven patients were treated in this study, 5 of whom achieved a visual acuity of 20/25 in the microtropic eye, while 2 patients had a final visual acuity of 20/30 in the microtropic eye. Five patients with one line difference in visual acuity can be accepted as quite a good response to amblyopia therapy, as reported by Lithander and Sjostrand.[32] However; none of our 7 treated patients showed alternation, even when amblyopia was successfully managed.

It is commonly stated that the sensory status of microtropia is irreversible and stereoacuity of 60 seconds of arc is unachievable.[1,2,21] However, some patients in whom microtropia disappeared after occlusion therapy[6,33] or spontaneously[34] have been reported. In our study, after treatment none of the 7 patients with occlusion treatment demonstrated improvement in stereocuity. Also, the Irvine prism test responses remained positive. As pointed out by Romano and von Noorden,[35] the Irvine prism test and tests for stereoacuity (random dot stereotests, but not contour stereotests) indicate real binocular cooperation. In our study, either deviation by the cover test or eccentric fixation monocularly by the visuscope persisted after treatment. On the basis of our findings, we conclude that amblyopia can be improved, but binocular defects of microtropia such as the absence of bifoveolar fixation, ARC, and defective stereoacuity cannot be improved.

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