Visual acuity and color vision deficiency in amblyopia

A.G. KOÇAK-ALTINTAS, B. SATANA, I. KOÇAK, S. DUMAN

Department of Ophthalmology, S.B. Ankara Hospital, Ankara - Turkey

PURPOSE. *To investigate color vision and its relation with the type of amblyopia and visual acuity of amblyopic eyes.*

METHODS. *In this prospective study, 67 amblyopic eyes of 64 patients, aged from 4 to 13 years (mean 6.8 ± 2.1) and 26 eyes of 13 control subjects aged from 5 to 13 years (mean 7.3 ± 1.6) were examined with the Farnsworth-Munsell 100 Hue Test (FM-100). Amblyopic eyes were grouped as strabismic (21 eyes) and anisometropic (46 eyes). Each group was subdivided according to their visual acuity, as less than 5/10 and 6/10 or better. The total errors, blue-yellow (B-Y) and red-green (R-G) partial error scores were obtained for each group. One-way ANOVA was used to assess differences between groups.*

RESULTS. *The error scores of all axes were lower in the control group than the amblyopic groups (p<0.001), but the differences within amblyopic groups were not significant (p>0.05).*

CONCLUSIONS. *Deficient color vision in the amblyopic eyes was not related to the visual acuity and type of amblyopia. (Eur J Ophthalmol 2000; 10: 77-81)*

KEY WORDS: *Amblyopia, Color Vision, Farnsworth-Munsell 100 Hue Test*

INTRODUCTION

Amblyopia is defined as a unilateral or bilateral decrease of visual acuity caused by vision deprivation or a pathological binocular interaction for which no organic cause can be detected by physical examination of the eye; in certain cases it is reversible with therapeutic measures (1). The extent of abnormalities of other visual functions and the involvement of the peripheral visual field in amblyopic eyes are less well understood, as the central visual field is affected preferentially (2). The most commonly recognized visual disturbance associated with amblyopia is decreased Snellen visual acuity (2). Reduced visual acuity in amblyopia may be accompanied by reduced contrast sensitivity, subnormal binocularity, crowding phenomena, nystagmus and abnormal electrophysiological findings in EVP (1-3).

The fovea, which is responsible for central visual acuity, acquires some of EVP features of the periph-

eral retina in amblyopic eyes. Therefore, functions such as visual acuity and contrast sensitivity are reduced in photopic conditions although they are in the normal ranges under scotopic and mesopic conditions. Color vision deficiencies in amblyopia are similar to the defects in determination of the peripheral retina of the normal eye (1-4).

We evaluated the relationship between visual acuity and color vision deficiency in amblyopia.

PATIENTS AND METHODS

We examined 67 eyes of 64 amblyopic patients who were followed up in the Pediatric Ophthalmology and Strabismus Department from January 1997 to January 1998, and 26 eyes of 13 patients as a control group. For 61 patients one eye, and 3 patients both eyes were included the study.

All patients underwent a complete eye examination.

Best corrected visual acuity was determined by E or letter optotypes on a Snellen chart. All patients received cycloplegic refraction, slit-lamp examination and direct ophthalmoscopic examination. Ocular alignment was determined using the alternate cover and cover-uncover test with prism.

Patients with eye diseases other than strabismus, anisometropia or amblyopia and who had paralytic strabismus, or vertical deviation were excluded. None of our patients had had occlusion treatment, penalisation or eye operation. The unreliable test results of non-cooperative patients were not included in this study.

Amblyopia was defined as a best corrected visual acuity of less than 0.8 on the Snellen chart. Strabismus was defined as a manifest deviation at distance through best optical correction and viewing on an accommodative target. Anisometropia was defined as a difference in refractive error (spherical equivalent) greater than ± 2.00 D between eyes. Combination amblyopia, in a subject with both anisometropia and strabismus, was excluded.

Patients with anisometropic amblyopia were divided into Group 1 who had 5/10 visual acuity or less, and Group 2 who had 6/10 visual acuity and better. Patients with strabismic amblyopia were divided in the same manner, Group 3 having 5/10 and less, Group 4 6/10 and better. An age-matched control group was set up, with 26 eyes of 13 cases with visual acuity of 10/10 in both eyes without refractive correction (Group 5). None of these controls had a history of ocular pathology, ocular operations or occlusion or penalisation therapy.

All cases underwent the Farnsworth-Munsell (Fm) 100 Hue test with illumination by a flourescent daylight lamp (Philips TLE 22W 54 Diurnal Circular). The test has 85 hues of similar colour and brightness, representing the full color circle. The hues vary gradually by approximately equal perceptual steps. The colored caps are arranged in four boxes and are numbered on the back.

Box 1. Red-orange-yellow (numbers 85-21)
Box 2. Yellow-green-blue (numbers 22-42)
Box 3. Blue-purple (numbers 43-63)
Box 4. Purple-red (numbers 64-85) (4-6).

The observer has to arrange each set of caps in order of hue in each box. The test was given monocularly on the same day with no time limit. Patients did the test with their better eye first and then with their amblyopic eye immediately after. In the control group right eyes were examined first. Although all subjects were examined for both eyes, only the worst eye of the 61 amblyopic patients and both eyes of the controls were used in statistical analysis. Only three patients' error scores were used in the statistical analysis for Group 1. The observer can make errors within a box but not between boxes.

The test is graded by assigning an error score to each cap, expressing the degree of mismatch between the cap and its neighbors (7-8). The total error score was the sum of scores for the four boxes and was divided into blue-yellow and red-green partial scores. The blue-yellow partial scores included errors in caps 1-12 12, 34-54 and 76-85. The red-green partial error scores included errors in caps 13-33 and 55-75.

All statistics were calculated using the square root of the total or partial error scores, a transformation which yields a normal distribution (9). One-way ANOVA was used to assess differences between the five groups, and multiple comparisons were made using Duncan's test.

We compared the results of the control group with the amblyopic groups to see whether there was a relation between the color discrimination and visual acuity and also within the types of amblyopia (anisometric or strabismic). We compared the four amblyopic groups with each other.

RESULTS

The patient's main data are given in Table I. There were no differences in age and sex distribution in the five groups. The youngest patient, aged four years, was in Group 1. He was well oriented to the test and his error scores were 116 (blue-yellow), 105 (red-green), 221 (total). Therefore, his error scores were included

TABLE I - BASIC DETAILS

	Amblyopic patients	Controls
Number	64	13
Male	29	7
Female	35	6
Age (yrs)	6.8 ± 2.1 (4-13)	7.3 ± 1.6 (5-13)

in the statistical analysis.

The means error scores for blue-yellow, and red-green and the total for the right eyes of the control group were 75.61 ± 11.3 (5-218), 61.69 ± 16.15 (7-159) and 137.61 ± 21.65 (16-37), and 53.53 ± 14.87 (0-129), 39.38 ± 10.07 (0-99) and 92.92 ± 26.87 (7-228) for the left eyes. The left eyes' error scores were lower than the right eyes', but the differences were not statistically significant (p>0.05), because of high standard deviation.

These results showed that testing both eyes did not give a training effect and there was no improvement in the second eye. Therefore, we could use the error scores of both eyes in the control group.

The error scores of both eyes of the three cases in Group 1 whose visual acuity and error scores were similar were included in the statistical analysis. The mean error scores in the blue-yellow axis were as follows. Group 1, 138.80 ± 90; Group 2; 119.85 ± 49; Group 3, l69.10 ± 106; Group 4, 134.09 ± 48 and Group 5, 67.76 ± 48.67. The error scores of the blue-yellow axis in the strabismic amblyopic Groups 3 and 4 were worse than in the anisometropic groups 1 and 2, and the worst scores were found in groups with lower visual acuity (5/10 or less). But the differences between the amblyopic groups were not statistically signifi-

cant (p>0.05).

The error scores of this axis were significantly higher in amblyopic groups than the control group with visual acuity 10/10 without optical correction (p<0.001).

The mean error scores in the red-green axis were as follows: Group 1, 107.12 ± 80; Group 2, 109.33 ± 43; Group 3, 144.20 ± 78; Group 4, 137.97 ± 74 and control group 59.88 ± 50. These scores were also worse in the strabismic amblyopic groups (3 and 4) than the anisometropic amblyopic groups 1 and 2. However, the differences were not significant (p>0.05). The error scores in the red-green axis were worse in groups with lower visual acuity than better visual acuity, but there was no real difference (p>0.05). The error scores in the red-green axis were significantly higher in the amblyopic groups than the control group (p>0.001) (Fig. 1).

The total error scores were the sum of the scores for the two axes. The mean total error scores were as follows: Group l, 245.92 ± 166; Group 2, 233.10 ± 87; Group 3, 313.30 ± 179; Group 4, 271.81 ± 116. No significant differences were found between amblyopic groups (p>0.05). The mean total error score in the control group was 127 ± 94. Differences between every amblyopic group and the control group were significant (p<0.001) (Fig. 1).
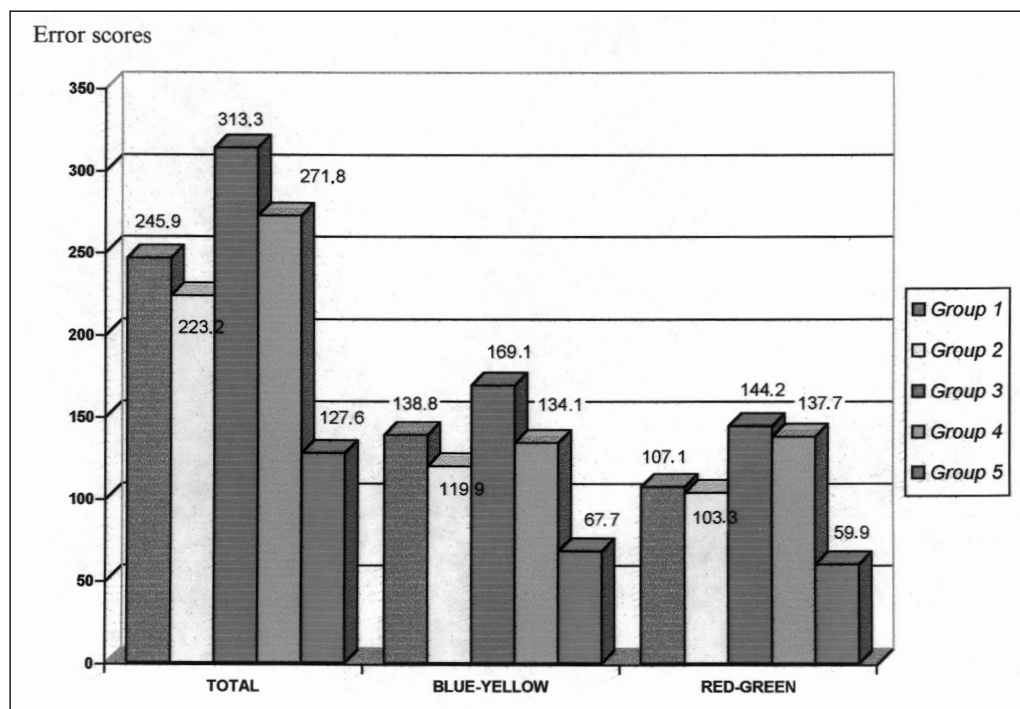

Fig. 1 - *Error scores of each group in FM-100 Hue test.*

DISCUSSION

The Farnsworth-Munsell 100-Hue test is widely accepted as the most sensitive and accurate test of chromatic discrimination, appropriate for widespread use in a clinical population (6,8-10). In 1963, the test was given using a MacBeth Easel lamp, and in 1984 Verilux (F15 T8 VLX) 15W fluorescent lamps were used (9). Nuzzi et al (11) used a halogen lamp (200m 250) and a fluorescent daylight lamp (Philips TLE 22W 54 Diurnal Circular). We executed the test under the same type of daylight lamp as Nuzzi et al.

Each patient is asked to arrange the sets of caps in order of hue. Pokorny and Smith (10) suggested that in practice this is achieved by only 1-2% of the normal population. Verriest et al (12) established age norms for color vision and showed optimal discrimination with an average error score of 40 for age 20-29 years, followed by an increase of approximately 15 errors per decade thereafter.

The test has been used to detect color vision disturbance in various conditions, such as increased intraocular pressure, optic neuritis, papiledema, diabetic retinopathy, pigmentary retinal degeneration, chorioretinal inflamation and age-related maculopathy (8, 10, 13). Color vision defects are common in amblyopia, especially when it is severe (1). Karadeniz et al (5) performed the FM 100 Hue test on 23 anisometropic patients aged 7-17. They found a mean error score for normal eyes of 137.43 ± 64.3 and the mean of the amblyopic eyes was 190.39 ± 85.8, the difference being statistically significant (5). Gezer et al (4) reported lower contrast sensitivity in strabismic amblyopia than in the normal population though the red-green and blue-yellow axis. Reduction of the blue-yellow axis was also more significant. Additionally, they showed impaired achromatic contrast sensitivity.

In our study, the total error score of 127.64 ± 94 for the normal population was close to the errors reported by Karadeniz et al (5) in a younger group. These two reports' gave scores higher than the optimum score of 40 for maximum performance in the third decade. The relatively poor results of our normal subjects may be due to their young age (9, 12). Error scores through the total, blue-yellow and red-green axes in amblyopic groups were higher than in the control group. Color vision deficiency was not specific to any color axis.

These findings suggested that amblyopic patients may have color vision pathologies. In order to investigate the relation between color vision deficiencies and visual acuity, amblyopic patients were grouped according to their visual acuity as 5/10 and less, and 6/10 and better. The error scores for all axes were better in groups wlth higher visual acuity but the difference was not significant. This result did not statistically support the idea of color sense abnormalities, especially in severe amblyopia (1).

Even though all the error scores in the strabismic group were worse than in the anisometropic group, no significant difference was present. Trichromatic vision extends 20 to 30 degrees from the part of the fixation (7). We did not take into consideration eccentricity of fixation in the strabismic group but all patients had central fixation in the anisometropic group. Therefore, abnormal color sense in amblyopia could not simply have been a function of the eccentric fixation (1).

About 75% of cortical visual cells are binocular and many of these are affected by amblyopia (14, 15). Since the binocular cortical cells responsible for vision in the amblyopic eye are also responsible for vision in the contralateral eye, the non-amblyopic eye may not be normal, as reported previously (14-16). We did not compare amblyopic and non-amblyopic eyes in the same subjects. The amblyopic eyes were compared with normal eyes with 10/10 visual acuity and with no history of amblyopic therapy. All subjects were tested in both eyes. To permit adaptation of eyes with lower visual acuity, the better eye was tested first in amblyopic cases and the results of these eye were included for statistical analysis in the amblyopic group. Only the error scores of both eyes of three cases in group 1 were used since their results were quite similar. In the control group, the left eyes were tested after the right, and the differences were minimal. Therefore, better results in the control group cannot be due to practice or a learning effect.

Color vision deficiency in males is reported to be much more frequent than in females (8%-0.4%) (7). The sex distribution of our amblyopic and control subjects was similar so the results may be affected equally by sex in all groups.

Amblyopia is not only a reduction of visual acuity

Koçak-Altintas et al

but may include other parameters which also affect quality of color vision (1, 4, 5). In addition to the improvement of visual acuity by amblyopia therapy, improvement in color vision should be investigated with prospective studies.

Reprint requests to:
Ayse Gül Koçak Altintas, MD
Department of Ophthalmology
Ankara Hospital
Kenedi cad 72/12
Kavaklidere, Ankara
06660 Turkey

REFERENCES

1. Von Noorden GK. Binocular vision and ocular motility: Examination of patient-III sensory signs symptoms and adaptation in strabismus. St Louis: Mosby Co, 1990; 219-31.
2. Hanad R, Senpiel F, Blakemore C. Physiology of suppression in strabismic amblyopia. Br J Ophthalmol 1996; 80: 373-77.
3. Gezer A, Sezen F. Bayrakçeken F. Amblioparda farkli renk ve isik kosullarinda görme keskinligi. XXV. Uhisal Oftalmoloji Kongresi Bülteni 1991; 244-7.
4. Karadeniz S, Sezen F, Alacali N, Mansu G. FM-100 Hue testi ile arastinlan renk görme sonuclanmiz. TOD XIL Kis Sempozyumu, Antalya 1989; 136-9.
5. Victor J. Evaluation of poor performance. An Asymmetry in FM-100 Hue Test. Invest Ophthalmol Vis Sci 1988; 29: 476-81.
6. Kir N, Gezer A, Gücükoglu A, Sezen F. Pseudofaklarda degisik renk ve illuminasyon kosullarinda görme keskinligi XXV. Ulusal Oftalmoloji Kongresi Bülteni 1991: 248-51.
7. Mein S, Horcourt B. Prognosis and management of ocular motility disorders. Blackwell Scientific Publication 1988; 14: 35-6.
8. Dow NW, Hort VM. Color vision. Adler's physiology of the eye. In: Hart WM, ed. Missouri: Mosby Co, 1987; 580-1.
9. Lugo M, Tiedeman JS. Computerized scoring and graphing of the Farnsworth-Munsell 100 Hue color vision test. Am J Ophthalmol 1986; 101: 469-76.
10. Pokorny S, Smith VC. Eye disease and color defect. Vision Res 1986; 26: 1573-84.
11. Smith VC, Pokorny J, Poss AS. Color axis determination on the FM-100 Hue test. Am J Ophthalmol 1985; 100: 176-82.
12. Pokorny J, Smith VC. Color vision and night vision. Retina. In: Rayan SS, ed. St. Louis: Mosby Co, 1989; 118-20.
13. Color vision basic and clinical science course in American Academy of Ophthalmology, San Francisco 1996; 18-127.