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Assessment of Color Vision in Amblyopes Using D15 Test

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Objective: The study was done on fifty Amblyopes because amblyopia being one of the common vision threatening disorders, is also associated with defective color vision. The objectives included in the study were to study the association between amblyopia and color vision using D-15 test and to find out the correlation between different types of amblyopia and color vision deficiency.

Materials and Methods: The study involved diagnosis of amblyopia, assessing color vision of amblyopia using Farnsworth D-15, by using structured Proforma in the months of August, September and October 2014. Color vision tests were performed on 50 people aged 7 years to 40 years of both genders.

Results: Amblyopic patients performed well in D-15 color vision test. Different types of amblyopia were assessed to find type of deficient color vision. Out of 50 patients, 21 amblyopes were associated with normal color vision on D-15 test.

Conclusion: The study has concluded that color vision is not affected in amblyopia and the study has also shown that there is no significant correlation found between type of amblyopia and color vision when assessed with D-15 color vision test.

Key words: Amblyopia, color vision, D-15 color vision test

Introduction:

Amblyopia comprises of two Greek words 'amblyos' meaning Dull and 'Opia' means vision[1]. It is a visual disorder in which decrease in visual acuity in one eye or both eyes occur due to insufficient stimulation of central or peripheral retina. It is most commonly seen to occur in primary visual cortical area when asymmetrical input flows from one or both eyes. It is also known as lazy eye. It is not associated with any defined organic pathology in visual pathway. It is therefore important for an ophthalmologist or optometrist to test for ocular pathology before diagnosing for the lazy eye.

Amblyopia is known to be a reversibly defected or deficiency of visual acuity which needs to be corrected before visual maturation[2]. Failure to diagnose and manage amblyopia before visual maturation of the child, which can be done by either occlusion therapy or penalization, leads to severe and long living visual impairment. Amblyopia is in fact a phenomena occurring in the visual cortex primarily when asymmetrical stimulus from both eyes flow into the primary visual cortical area 17. Several vision processing at cortical level deprive visual stimulus especially at the level of primary visual cortex area (V1) resulting in abnormal spatial vision in amblyopic eye[3]. The Lateral geniculate nucleus of thalamus show abnormalities in its structure and function resulting in amblyopia[4]. Amblyopia was previously considered to be occurring in one eye but now it seems to be a disorder presenting in both eyes primarily[5].

The lazy eye is indicated by unilateral or rarely bilateral decreased visual acuity[6]. It is the common cause of reduced vision unilaterally in children and adults[7]. Amblyopia is also responsible for reduction in depth perception and in contrast sensitivity of a person[8].

The parvocellular pathways of Amblyopes for chromatic stimulus are damaged. Ocular trauma in young children and age related macular degeneration in adults results in bilateral blindness which is the long standing consequence of lazy eye[9].

Amblyopia seems to be occurring due to suppressed visual stimulation during critical period of visual development after birth. There may be difference of two lines in the vision of both eyes of a person when visual acuity of the patient is examined by the examiner. Amblyopia is not a cause of eye pathology but it is due to an abnormal interaction between the two eyes in early childhood[10]. Thus the brain is unable to favor the information and images seen by the suppressed[11]. This abnormal visual interaction before visual maturation has negative or harmful effects in adulthood like problems associated with hearing or auditory problems and integrated visual problems[12].

It is a vital pediatric disorder in orthoptic and ophthalmology and prevalence of amblyopia is estimated to be 3%. A decrease in visual acuity does not always diagnose amblyopia. It is an outcome of disorders like strabismus and uncorrected refractive errors during early visual development in childhood[13].

Amblyopia is clinically classified into:

- Strabismic amblyopia which is due to dissimilar foveolar images in the presence of any deviation at distance and near.
- Ametropic amblyopia which is caused by refractive errors in both eyes.
- Anisometropic amblyopia that occurs because of difference in refractive error of the two eyes causing blurring of foveal images in one eye.
- Meridional amblyopia that occurs in eyes with astigmatism which is not corrected or having different cylinder power between the two eyes.
- Stimulus deprivation amblyopia that is caused by opacities in visual media[14-16].

The color of the objects can be said as the emitted or reflected wavelength from their surface. Vision is the ability to see. Color vision is the ability of eye that allows us to differentiate equally bright surfaces or different shades of objects around us or color discrimination is an individual's ability to perceive shades of different hues. Perception of color includes absorption of light which is in fact the first step of color processing. The stimulus flows through lateral geniculate nucleus to the primary area of visual cortex and to the secondary visual area of cortex. The stimulus flows to visual area IV of cortex and to the areas anterior to cortical area IV. Further chromatic processing occurs inside the inferior temporal cortex[17]. Visual processing stages shown by the color vision theory include: Prereceptoral filters associated to lens, macular pigment, and cone, Photopigments e.g. L-cones, M- cones, and S-cones and Postreceptoral processes e.g. red-green channels, S-cone channels, and luminance channels. The human brain contains multiple ventral visual areas encoding for color[18]. Changes in Prereceptoral filters, or reduced mass of cone Photopigments or distracted Postreceptoral processes may lead to deficient color vision[19].

Our retina is responsible for color perception of different objects as it contains photoreceptors (cones) of three types i.e. long, middle and short wavelength sensitive which are sensitive to blue, green, and red wavelengths of light[20]. Researchers have evidenced that color vision deficiencies are associated with genetic encoding of cone photoreceptor pigments which are sensitive to all three wavelengths i.e. blue, red and green[21]. Deficit color vision may cause an individual to abnormally judge and match a color or is unable to discriminate colors of different hues. Color vision defects

are also produced by many visual disorders such as amblyopia. In cases of complete acromatopsia, color vision is totally diminished due to brain damage. Cortical damage causes central color vision loss and commonly related to stroke[22]. Human brain contains multiple ventral visual areas coding for color vision[18].

The history of evolution color vision testing goes back to 1700s and so since then comparing color nomenclature has got replaced by many classical methods[23]. Clinical assessment of congenital and acquired color vision deficiencies require a basic design for the structure and function of the clinical color vision tests.

Color vision tests are divided into the following subtypes:

- Pseudoisochromatic plate tests used for normal and defective color vision in which figures or printed letters having altered color from the background are recognized by the viewer or observer.
- Arrangement test as indicated by its name that colors are arranged according to their hue.
- Matching tests in which two matching or similar colors are adjusted.
- Naming tests
- Lantern tests are performed in a dark room in which a person is asked to name small lights which are used as point sources.
- Anomaloscopes[23, 24].

The tests used to measure color vision include:

Farnsworth-Munsell (FM) 100 hue uses 84 discs of colors, into groups of four. The Farnsworth Munsell Dichotomous D-15 test is used for chromatic defects in vision. Ishihara Pseudoisochromatic test plates for congenital defects in color. The Lanthony New color test is used for testing hue and anamaloscope which is considered to be the gold standard for the diagnosis of color vision[5].

Although Ishihara test was initially used to identify the congenital color vision blindness which are commonly known to be red-green defects, it can also be used to identify acquired color vision defects and is known to be succeeded in early diagnosing of the chromatic defects[26].

The Farnsworth Munsell Dichotomous D-15 test is helpful in differentiating between hereditary and acquired color vision defects. Symmetrical results of both eyes indicate congenital defects and asymmetric results indicate acquired color vision defects[27].

The D-15 test is short form of FM 100 test (containing a referred Cap and 15 discs of color) used for testing Protane, Deutane and Tritane which are the common color vision deficiencies, protane being red color deficiency, Deutane being green color deficiency and tritane being blue deficiency and achrometopsia which is complete loss of color vision or color blindness. Lack of functioning in L-cone due to absence of photopigment is characteristics of protane deficiency and Deutane deficiency is determined by absence of M-cone photopigment[20]. Tritane which is blue color deficiency occurs as a result of mutations in genes of S cone pigment which stands for short wavelength sensitive gene and molecular genetics has proved it to be progressive in nature[28].

Achromatopsia is rarer condition than protane and Deutane which are milder conditions [23]. Color blindness is a disorder associated with X-linked chromosomes[29].

When color vision is assessed in Amblyopes, they show bad performance while assessing color vision because the passage way for chromatic stimulus is damaged[29], as the neural pathway for occurrence of amblyopia and for color vision is common it is important to assess color vision of amblyopia. With the increasing age, amblyopic eyes show poor color vision and decreased visual acuity. Visual acuity is not responsible for reduced color vision in the lazy eyes[3].

Aims And Objectives:

1. To study the association between amblyopia and color vision using D-15 test.
2. Find out the correlation between different types of amblyopia and color vision deficiency.

Materials & Methodology:

Study design:

Descriptive cross sectional survey

Inclusion criteria:

Amblyopes of all types aged 7 to 40 years

Exclusion criteria:

- Patients with other ocular disorders leading to reduced visual functions
- Patients with congenital color vision defects

Population:

All clients visiting Orthoptics Clinic, Pediatric Clinic and Refraction Room fulfilling inclusion criteria, Mayo Hospital Lahore

Sampling method:

Non **probability** convenient sampling

Sample size:

Fifty **patients**

Location of study:

College Of Ophthalmology And Allied Vision Sciences, Mayo Hospital Lahore

Duration of study:

The study took place from August to December 2014

Data collection method:

Informed consent was taken from the patients. After that instructions were given to the patients about the procedure. Patient's profile was asked. A detailed history of

the patient was taken with an emphasis on the onset of ocular symptoms, use of refractive correction, trauma and so on. Clinical examination of the patient was done by taking visual acuity of the patient using logMar visual acuity chart. Pen torch was used for external examination and to check squint. Refraction of the patient was taken using Retinoscope, when needed. Color vision of the patient was assessed by using D-15 colored discs and patient was asked to arrange the discs according to color matching. The results of color vision were recorded on the graph.

Results:

Figure 1: Frequency of type of amblyopia

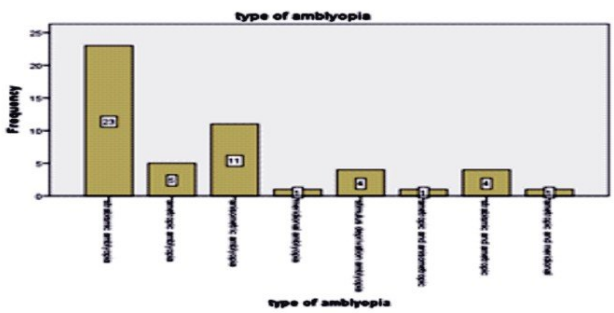


Figure 1 shows all different types of amblyopia observed in different amblyopic patients from above study. Out of 50, 23(46%) compromised strabismic amblyopia. 5(10%) cases were of Ametropic amblyopia. And 11(22%) patients belonged to Anisometropic amblyopia. 4(8%) patients belonged to stimulus deprivation amblyopia. Another interesting result was found in some amblyopes which were having more than one type of amblyopia. Four (8%) patients were strabismic and ametropic amblyopes. 1 patient was Ametropic and Anisometropic amblyope and 1 was having Ametropic and Meridional amblyopia.

Figure 2: Frequency of type of color vision deficiency

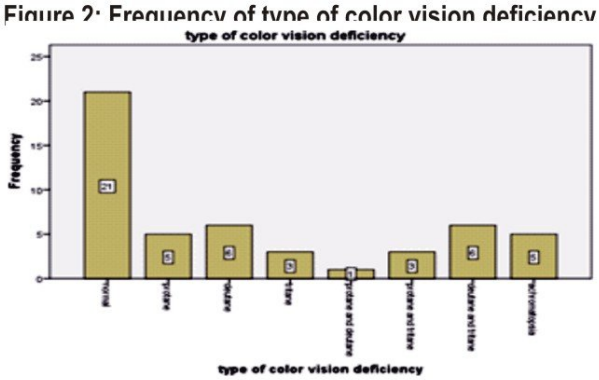
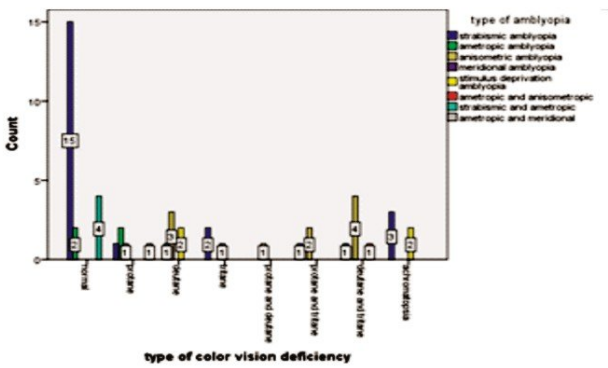


Figure 2 shows different frequencies which indicate different types of color vision deficiencies examined during color vision assessment in amblyopes. Out of 50 amblyopes examined 21 were normal, 5 were having protane deficiency, 6 were having Deutane and 3 were having tritane deficiency. One of the patients showed both protane and Deutane deficiency, 3 showed protane and tritane and 6 patients showed Deutane and tritane deficiency.

Fig.3: Type of Amblyopia versus colour vision deficiency



Out of 50 patients, 21 amblyopes showed normal color vision on D-15 tests.

Discussion:

Amblyopia is a sight threatening disorder which needs to be treated before visual maturation. Literature consists of many studies on visual functions (visual acuity, color vision, contrast sensitivity, glare sensitivity and visual field) and amblyopia. Many studies have been done on components of amblyopia like visual acuity and contrast sensitivity but least studies have been documented on the color vision component of amblyopia. Through this research, the color component of amblyopes has been studied and normal results have been concluded. The research has been done using D-15 color vision test because of easily availability of the test and is easily understood when performed. From the study it has been concluded that color vision component of visual function is not affected significantly in amblyopia. Furthermore the study has shown that there is no significant correlation found between type of amblyopia and color vision when performed with D-15 color vision test. However there are limitations of this study due to small sample size and limited time frame. More studies with diverse population should be undertaken to finally support or refute the association between amblyopia and colour vision deficiencies Amblyopia is a disorder with occurrence in early life, which in certain cases is difficult to diagnose as it occurs with no significant symptoms earlier. This study will help in early diagnosis of amblyopia before visual maturation of a child, as it has clearly explained the pathways for amblyopia occurrence and its causes. A practitioner can play an

important role in the society by securing the future of millions of children from this vision threatening disorder by early diagnosing the disorder.

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