The accurate colour vision is required for performing day to day activities with perfection. The colour vision deficiencies have a high prevalence and the reported prevalence of colour vision defects (CVD) is about 8% in males and 0.4% in females. But one fifth to one third adults are unaware of their colour deficiency as their vision is otherwise normal. The colour vision can be tested by using Ishihara’s Pseudoisochromatic Plates, Edridge’s Green Lantern, Anomaloscope, Holmgrens’ wool, the Richmond HRR 4th edition 2002 test, the Medmonth C-100 test and Farnsworth D 15 test, etc. Edridge’s Green Lantern (EGL) is the technique incorporated in Gazette of India for conducting medical examination of candidates before recruitment into government services related to different professions. Additionally, it is the most often used vocational test worldwide. Out of the various colour vision testing techniques, anomaloscope is considered to be the most accurate tool to classify color blindness and is considered gold standard.

The present study therefore was designed to compare the response of subjects on Edridge’s Green Lantern with their responses on anomaloscope for assessing colour vision and colour vision defects (CVD).

**MATERIALS AND METHODS**

The present study is a cross sectional and observation study carried out in Department of Ophthalmology, Guru Nanak Eye Centre and Maulana Azad Medical College, New Delhi. In this study 502 male subjects of Delhi in the age range of 10-50 years were enrolled. Only subjects having best corrected vision of 6/6 in each eye separately were taken. A detailed history was elicited to rule out factors which are known to affect colour vision like any significant ocular or systemic diseases or prolonged drug intake. The subjects having any significant ocular or systemic diseases...
like diabetes, glaucoma, macular degeneration and retinitis pigmentosa; or any prolonged intake of drugs like barbiturates, digoxin, chloroquine, ethambutol or phenytoin, were excluded. Any positive family history of colour vision defect was also recorded.

Ocular examination included recording of visual acuity. The subjects who did not have 6/6 vision in both eyes (separately) were subjected to proper refraction to acquire best corrected visual acuity (BCVA) of 6/6 in both eyes (separately). A detailed ocular examination was done to rule out any significant anterior or posterior segment abnormality.

Colour vision was tested with both testing techniques (Edridge’s Green lantern and Anomaloscope) on each subject – for each eye separately, while wearing full refractive correction. Though routine screening in schools and at other places is binocular but as eye diseases may affect each eye differently thus monocular testing was used. The subjects were explained both the procedures and it was made sure that they understood the test. The subjects were not allowed to wear “tinted” contact lenses or “tinted” glasses during examination.

Neitz Anomaloscope OT II having red wavelength of 670 nm, yellow wavelength of 588 nm and green wavelength of 545 nm was used for this study. This anomaloscope detects only red-green CVD. As the observers see two fields in a telescopic view, thus they were advised to use distance vision to see both the fields. The level and type of illumination was kept constant. Initially Linksz procedure was used. The examination was started with a three minute pre-adaptation to the lighted Trendelenburg screen on the front panel of the anomaloscope. Then the adaptation light was extinguished and the observer was presented with a normal match prepared by the examiner in advance. At this point, the patient/subject used both red-green and yellow controls to adjust the two fields to equality. The next stage was to evaluate the range of acceptable red-green ratio values which matched with scale units of yellow from 0-73. The parameters noted for subjects include the matching range and the match midpoint (Aq). The match range is defined as the obtained range of settings under neutral adaptation. The match midpoints are converted into anomalous quotients (Aq) or comparative scores by anomaloscope itself and these appear on screen of anomaloscope.

For Edridge’s green lantern, a combination of colours (dark red, red, yellow, green, signal green, blue, purple and white) was shown through apertures of two extreme sizes i.e. 1.3 mm to 13 mm, in “disc 1” to a subject in dark room at distance of 6 m. The subjects were asked to identify various colours. A record was be made for colours identified/not identified through these apertures. The colour perception of subjects was graded into a higher and
lower grade colour perception according to the size of aperture (1.3 mm or 13 mm) in lantern through which the colour was correctly identified.

The results of two tests in terms of colour vision normal, colour vision defective and type of colour blindness were compared. As this model of anomaloscope detects only red-green CVD, thus agreement between Edridge Green lantern and anomaloscope for pure green, pure red, signal green or dark red for both right eye and left eye tested separately was found out.

**RESULTS**

A total of 502 normal male subjects attending the out-patient department of Guru Nanak Eye Centre, New Delhi, were included in this study. None of the subjects had any disease which is known to affect colour vision status, or positive history for any drug intake. Two out of 502 subjects had positive family history of CVD. None of the patients had any anterior segment or posterior segment abnormality.

The age range of subjects was 10-50 years and maximum number of subjects fell within age group of 20-30 years (32% of total subjects) and the mean age of all subjects was 29.73 years (±10.98 SD). About 85 % of our subjects were emmetropic and factually very few subjects required correction of more than ± 4 D. The range of intraocular pressure in right eye was 11-20 mmHg (mean 15.45 ± 3.01 mmHg) and the range of intraocular pressure in left eye was 12-20 mmHg (mean 15.53 ± 2.41 mmHg). There was no statistically significant difference for mean IOP between normal subjects (as declared with anomaloscope) and subjects having colour vision defects for both right eye (p=0.760) and left eye (p=0.837) separately.

It was found that 473 subjects were classified as normal and 29 subjects were classified as colour vision defective by anomaloscope. The prevalence of blindness was 5.8% (29 colour blind in 502 subjects) as studied on anomaloscope. Out of these subjects, 13 (2.6 %) subjects had deuteranopia, 8 (1.6%) subjects had deuteranomaly, 6 (1.2%) had protanopia and 2 (0.4%) subjects had protanomaly. As the response of both eyes (right eye and left eye) were same on anomaloscope thus responses were not calculated separately.

On the other hand, on Edridge Green Lantern, the response of right eye and left eye were different. Additionally prevalence of blindness in Edridge Green Lantern was found out by using varied criteria.

While qualitatively evaluating CVD, it was found that the prevalence of colour blindness on Edridge Green lantern in right eye was 24 (4.78%) and in left eye was 27 (5.37%) when blindness to “either or both colours of pure green and pure red” was examined. On splitting the results, it was found
that in right eye, number of colour blind to “only pure green” were 16 (3.18%), number of colour blind to “only pure red” were 2 (0.39%) and number of colour blind to “both pure red and pure green” colours were 6 (1.19%). In left eye, number of colour blind to “only pure green” were 18 (3.58%), number of colour blind to “only pure red” were 2 (0.39%) and number of colour blind to “both pure red and pure green” colours were 7 (1.39%).

The prevalence of CVD on Edridge Green lantern in right eye was 22 (4.38%) and in left eye was 25 (4.98%) when blindness to “either or both colours of signal green and dark red” was examined. In right eye, number of colour blind to “only signal green” were 16 (3.18%), number of colour blind to “only dark red” were 1 (0.19%) and number of colour blind to “both signal green and dark red” colours were 5 (0.99%). In left eye, number of colour blind to “only signal green” were 20 (3.98%), number of colour blind to “only dark red” were 1 (0.19%) and number of colour blind to “both signal green and dark red” colours were 4 (0.79%).

On the other hand, when criteria of aperture size was used and if those subjects who could not see even single colour correctly through 1.3 mm were taken as colour vision defective, then prevalence of CVD in right eye was 35 (6.97%) and left eye was 32 (6.37%) whereas for anomaloscope this prevalence rate was 5.8% in both eyes separately. The Edridge Green lantern could not divide subjects into deuteranopic, deuteranomalous, protanopic and protanomalous.

Thus the prevalence rate of colour vision defectives by Edridge Green lantern varied from 22-35 (4.38% to 6.97%) when different criteria were used.

If high grade and low grade perception was seen, then the number of right eyes having high grade perception (out of 8 ≥ 4 colours seen correctly by 1.3 mm aperture) was 480 (95.61%) and low grade perception (out of 8 < 4 colours seen correctly by 1.3 mm aperture) was 22 (4.38%). The number of left eyes having high grade perception (out of 8 ≥ 4 colours seen correctly by 1.3 mm aperture) was 476 (94.82%) and low grade perception (out of 8 < 4 colours seen correctly by 1.3 mm aperture) was 26 (5.17%).

In Edridge Green Lantern, subject who committed even one error on 1.3 mm aperture for recognizing colour was taken as “colour blind/colour vision defective”. On comparison of results of Edridge Green Lantern for colour vision normal and colour vision defective with results on anomaloscope, it was found that all subjects diagnosed colour vision normal with Edridge Green Lantern were found colour vision normal on anomaloscope and all subjects found colour vision defective with Edridge Green Lantern were found colour vision defective on anomaloscope. Thus sensitivity for Edridge Green Lantern comes 96.6% and specificity comes 97.7% (p<.001) and measure of agreement kappa value is 0.823 which is excellent.
The subjects who could not identify pure green/pure red/signal green/dark red through 1.3 mm aperture were considered blind to these colours. The agreement of Edridge Green lantern (when blindness to “both pure green/pure red” was considered) with anomaloscope for right eye had kappa value of 0.754 and for left eye had kappa value of 0.757. The agreement of Edridge Green lantern (when blindness to “both signal green/dark red” was considered) with anomaloscope for right had kappa value of 0.734 and for left eye had kappa value of 0.805.

DISCUSSION

The ability to make differentiation of observed colours is an important physiological requirement in certain professions specifically shipping, thus EGL is the most frequently used vocational test. This EGL test was originally designed to reproduce typical ships’ lights at a certain distance and simulate signals. The present model of EGL is a funnel-shaped colour perception test lantern with rotating colour discs, fitted for electrical illumination. Many colours are installed in lantern to test for occupational requirements of any service or branch of a service. The modifying filters simulate foggy, rainy, smoky and other meteorological conditions while difference in size of apertures simulates changes in distance. However, there is paucity of literature on correct method for using Edridge Green lantern and criteria for defining CVD with use of EGL are not specified.

As 85% of our subjects were emmetropic, we feel that results of our study were not influenced by refractive errors. Additionally there was no statistically significant difference for mean IOP between normal subjects (as declared with anomaloscope) and subjects with CVD for both right eye (p=0.760) and left eye (p=0.837) separately, thus no subject had high intraocular pressure which could have confounded our results. The previous Indian studies have not measured IOP in their subjects studies for colour vision defects. Majority of Indian studies on colour vision defectives have been carried with Ishihara’s plates only, while Naresh studied his subjects with anomaloscope additionally. However, to the best of our knowledge, there is no Indian study for comparing colour vision responses on EGL with those on anomaloscope.

While different population groups including Jat Sikhs of Patiala city, Brahmins of Madhya Pradesh, Punjabis of India and Muslims and Mahajans have been studied, this is the first study in Delhi male subjects. Kulshrestha and Madan, found a lower incidence of CVD in Rajasthani population as people belonging to this state especially in the arid and semi-arid areas are subjects to the operation of natural selections as seen in primitive population, which was suggested by Post in his classical theory.
Our study shows higher incidence of colour blindness in Delhi urban males than other population groups studied in earlier studies, and our study thus supports the selection relaxation hypothesis of Post\textsuperscript{13} and Pickford.\textsuperscript{14}

The prevalence rate of CVD with Edridge Green Lantern in our subjects varied from 4.38\% to 6.97\%, when different criteria were used while it was 5.8\% with use of anomaloscope. As the prevalence rate of colour vision defects by Edridge Green Lantern is more than that with anomaloscope, thus this would instigate us to test the hypothesis whether blindness to other colours (other than red and green) exists, but it gets failed to be diagnosed on anomaloscope. The present day models of anomaloscope are in fact designed to detect only red and green blindness. Hovis and Oliphant\textsuperscript{1} found that 97\% subjects diagnosed CVD and 2.3\% declared normal by anomaloscope – failed lantern test. We also found different results with use of two techniques.

Kulshrestha and Madan\textsuperscript{7} said that it is difficult to make people understand colours of EGL. Additionally subjects diagnosed as colour vision defectives to red/green with anomaloscope could however detect these colours through 13 mm aperture of EGL. We found the prevalence of colour vision defect with EGL to be more than that found by use of anomaloscope when 1.3 mm aperture of EGL was used. Additionally, prevalence of CVD with 1.3 mm aperture of EGL is found to be more than that found with 13 mm aperture.

The response of both eyes (right eye and left eye) were same on anomaloscope while it was not so for Edridge Green Lantern, in which the response of right eye and left eye were different. None of the Indian or international study\textsuperscript{4,7,11,12} has given results on CVD in two eyes separately.

Linksz\textsuperscript{15} found that EGL cannot classify subjects into deuteranopic, deuteranomalous, protanopic and protanomalous. We also found same results with EGL.

Solandt and Best\textsuperscript{16} said that subjects who failed other tests but passed EGL test were in fact anomalous trichromats with slight defect.

The Gazette of India\textsuperscript{2} recommends use of 1.3 mm aperture of EGL for testing presence of high grade colour perception and 13 mm aperture of EGL for testing presence of low grade colour perception. However criteria for defining CVD with EGL are still not specified. Prevalence of CVD as found by EGL is different from anomaloscope and this prevalence varies with criteria used in EGL. Additionally, EGL is not useful to determine the severity of CVD (anomaly or anopia. But in EGL there is freedom to install any colour, thus lanterns tests the safety needs for actual job. On this account it may still remain as most commonly used vocational test.
REFERENCES


