Assessing contrast sensitivity change in retinal diseases with use of yellow-amber NoIR glasses

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Purpose: The purpose of this study was to assess change of contrast sensitivity (CS) in subjects having retinal diseases with yellow-amber no infrared (NoIR) glasses used as low vision aid (LVA). Methods: We examined CS in 82 low vision (LV) subjects having retinal diseases with Pelli Robson Chart at 1 m distance before and after wearing yellow-amber NoIR glasses. We also found type of retinal affection and macular optical coherence tomography (OCT) features. Results: The distance and near best-corrected visual acuity (BCVA) was, respectively, 0.68 ± 0.17 (median = 0.70) and 0.72 ± 0.25 (median = 0.70) logmar units. The pre-LVA CS was 0.52 ± 0.29 (median = 0.3) and post-LVA was 0.52 ± 0.28 (median = 0.45) logunits (mean reduction = 0.002 ± 0.24; Median reduction = 0; P = 0.909). The pre-LVA and post-LVA CS showed a negative correlation with logmar distance BCVA [r = -0.090; P = 0.317 and r = -0.152; P = 0.090 respectively]. The pre-LVA and post-LVA CS showed a negative correlation with logmar near BCVA [r = -0.114; P = 0.207 and r = -0.054; P = 0.549 respectively]. The CS did not improve in subjects having macular degeneration, pathological myopia, hereditary maculopathy, and diabetic retinopathy. The macular OCT features like fluid, exudates, scars, drusens, traction, and hole did not significantly influence CS both at pre-LVA and post-LVA stage. Conclusion: This is the first study with yellow-amber NoIR glasses which blocks "both ultraviolet and infrared light." The subjects having macular degeneration, pathological myopia, hereditary maculopathy, and diabetic retinopathy did not improve in CS with filters. The correlation values showed that filters may improve CS in subjects having good baseline BCVA.

Key words: Contrast sensitivity, low vision, low vision aid, retinal diseases yellow filter, visual acuity, yellow-amber NoIR glasses

Real-world vision consists of objects having a wide range of sizes viewed under various visually degrading conditions, such as fog, night time, and bright sun. The defective contrast sensitivity (CS) leads to difficulty in the night driving, going down the stairs, watching television, or reading.

The CS tests usually involve presenting letters or digits adjusted to become increasingly similar in brightness to the background until one can no longer see them. The CS is a more comprehensive measure of functional vision than is standard Snellen acuity (SA) as CS tests help to identify vision loss from a variety of disorders, many of which SA tests fail to detect, as SA tests measure visual acuity (VA) only at “high contrast.”

The authors have rarely studied CS in low vision (LV) subjects.[1] Rosenblum et al. and Carracedo et al. found that yellow and amber filters improved VA and CS in their LV subjects.[2,3] Other found no significant improvement in CS with filtering lenses of different shades.[1,4] Out of them, Albarran et al.[3] evaluated CS through lenses having a transparent center with tint only in the peripheral part, though CS requires central vision; thus, there was no change in CS. Lavric et al.[4] stated that 500–600 nm light wavelength is needed to be filtered to improve CS in photopic conditions, but blue-light filtering lenses used by their subjects did not do so. Eperjesi and Agelis[5] stated that reduction in VA and CS with filters is most likely due to a reduction in total light transmission and a subsequent decrease in retinal illuminance. Due to the variable effect of tint on illumination, pupil size, and scattering, it becomes difficult to recommend using these lenses, especially for activities like night driving.[1]

We assessed CS in subjects having LV due to retinal diseases and looked for any change in CS using yellow-amber no infrared (NoIR) glasses worn over distance refractive correction. The yellow filter, which blocks “both ultraviolet and infrared light” to reduce scattering for giving high luminous transmittance and better contrast, has not been studied as low vision aid (LVA) in the past. We also found the type of retinal affection in subjects showing no improvement in CS with use of LVA. The influence of macular optical coherence...
tomography (OCT) features on CS values before and after wearing yellow-amber NoIR glasses was examined.

Methods

A cross-sectional observational study, without control, was conducted at the Department of Ophthalmology on LV patients attending Retina Clinic. The institutional ethical committee approved the study (vide number F. No. 17/IEC/MAMC/2017/ Ophtha./01) and each participant gave written informed consent. The medical research was conducted according to the World Medical Association, Declaration of Helsinki.

A total of 82 LV patients, in the age group of 20–70 years, having retinal diseases like age-related macular degeneration, choroiditis, heredo-macular degeneration, diabetic maculopathy, and pathological myopia were enrolled. We excluded subjects with significant media opacity like corneal opacity or cataract and vitreous hemorrhage; other coexisting ocular diseases like thyroid ophthalmopathy and optic atrophy; and central nervous system disease. We elicited a detailed personal history regarding visual symptoms of defective near and distance vision, defective color vision, glare, difficulty in seeing at night, in the sun, and foggy conditions.

The subjects underwent detailed oculair examination for baseline evaluation of visual functions. The reading obtained from the auto-refractometer followed by retinoscopy gave a refractive error. We calculated just noticeable difference (the amount of spherical lens power needed to elicit an appreciable change in clarity or blur) from the denominator of the 20 foot SA. We added an appropriate plus/minus lens over this correction to get a final prescription for near and distance.

The best-corrected distance acuity (BCVA) was tested on self-illuminated Early Treatment Diabetic Retinopathy Study (ETDRS) acuity charts at 4 m, under uniform illumination, and ETDRS acuity log score, which patients could read completely, was recorded. The subject underwent near vision testing using ETDRS near charts in the text printed in high contrast, at a reading distance of 40 cm, using optimal illumination with recommended glass prescription. All subjects used the same reading material having the same contrast, illumination, letter spacing, and font style.

We tested CS on Pelli Robson Charts (86 × 63 cm chart). It consists of 16 triplets of 4.9 cm (2.8° at 1 m) letters and assesses CS at a spatial frequency of about 0.50 to 1 cycle/degree. The letters have the same contrast within each triplet, and the contrast in each successive triplet decreases by a factor of 0.15 log units. The score ranges from 0.25 (least score) to 2.00 (best score). The study subjects read the chart at 1 m while wearing distance correction and obtained the baseline CS result according to the last triplet seen. Then, the subjects wore “side-covered” yellow Amber NoIR glasses over the distance correction, and they were re-evaluated on Pelli Robson Charts for improvement/otherwise in CS. The primary outcome variable was improvement/change in CS.

Statistical method

Data was entered in Microsoft Excel and analyzed using Statistical Package for Social Sciences Version 25.0 (IBM Corporation, Chicago, IL, USA). Because data is nonparametric, we found median and an interquartile range (IQR) for variables and statistical significance of difference between pre-LVA and post-LVA using the Wilcoxon sign-rank test. We calculated correlation coefficients between distance and near BCVA with pre-LVA and post-LVA CS using the Spearman’s correlation coefficient and examined r values for statistical significance. The difference was accepted as statistically significant (SS) only when the P value was less than 0.05; otherwise, it was not statistically significant (NSS).

Results

In a cross-sectional observational study, without control, conducted in the Department of Ophthalmology, 82 LV subjects, in the age range of 20–70 years, were assessed for improvement/otherwise of CS with the use of LVAs in the form of yellow-amber NoIR glasses. The subjects underwent detailed ocular examination to assess distance BCVA, near BCVA, and CS at baseline and following use of relevant LVA.

The mean age of our subjects was 48.25 ± 18.36 years (range 20–70 years). There were 55 (67.85%) males and 27 (32.14%) females. A total of 27 (32.14%) subjects had systemic diseases including diabetes (n = 15), hypertension (n = 10), and thyroid disease (n = 2). There was no family history of any systemic disease. All the subjects had defective distance and near vision and experienced difficulty in seeing at night. Out of 82 subjects, 35 (41.66%) subjects had glare.

The baseline evaluation showed that distance refractive error varied from -2.0 to +3.50 D. The distance BCVA following refractive correction varied from 20/200 (logmar 1.00) to 20/63 (logmar 0.48); mean distance BCVA being 0.68 ±0.17 (median value = 0.70; IQR 0.48, 0.78). The baseline evaluation showed that near refractive error varied from 0 to +3.50 D. The near BCVA following refractive correction varied from 20/400 (Logmar 1.3) to 20/40 (Logmar 0.3); mean near BCVA being 0.72 ± 0.25 (median value = 0.70; IQR 0.60, 0.90).

The CS before wearing yellow-amber glasses varied from 0.3 to 0.9 (mean value 0.52 ± 0.29) (median value = 0.3; IQL 0.3, 0.9). The CS scores recorded after wearing of yellow-amber NoIR glasses varied from 0 to 0.9 (mean value 0.52 ± 0.28) (median value = 0.45; IQR 0.3, 0.9). There was a mean reduction in CS post-LVA of 0.002 ± 0.24 (Median value for change = 0; IQR 0, 0), but this was NSS (p = 0.909) [Fig. 1]. We took cut off value of CS as 1.5[7] and classified subjects into lower (<1.5) and normal CS (≥1.5). None of the eyes had CS values above 0.9 before or after wearing yellow-amber NoIR glasses.

A total of 16 subjects (21 eyes; 16.8%) had reduced CS score values after wearing yellow-amber NoIR glasses. Table 1 shows the distribution of these subjects along with their disease condition.

We additionally found correlation values between pre-LVA CS and post-LVA CS with distance and near BCVA [Table 2].

Table 2 shows that pre-LVA CS scores values had a negative correlation with Logmar BCVA distance (r = −0.090; P = 0.317; NSS) and baseline CS scores values had a negative correlation with Logmar BCVA near (r = −0.114; P = 0.207; NSS). Similarly CS post-LVA scores showed a negative correlation with Logmar BCVA distance (r = −0.152; P = 0.090; NSS) and CS post- LVA scores had a negative correlation with Logmar BCVA near (r
Figure 1: Mean contrast sensitivity scores at pre-LVA and post-LVA

Table 1: Distribution of eyes having a reduction in CS score values after using yellow-amber NoIR filter

| S. No. of eyes | Age | Disease               | Pre-LVA | Post-LVA |
|---------------|-----|-----------------------|---------|----------|
| 1             | 65/M | Dry ARMD              | 0.9     | 0.3      |
| 2             | 50/F | Dry ARMD              | 0.9     | 0.3      |
| 3             | 68/M | Wet ARMD              | 0.9     | 0.6      |
| 4             | 68/M | Wet ARMD              | 0.9     | 0.6      |
| 5             | 65/M | Dry ARMD              | 0.9     | 0.3      |
| 6             | 21/M | Hereditary maculopathy| 0.3     | 0.15     |
| 7             | 70/M | Dry ARMD              | 0.9     | 0.3      |
| 8             | 67/M | Macular degeneration  | 0.9     | 0.3      |
| 9             | 62/M | Pathological myopia    | 0.9     | 0.3      |
| 10            | 62/M | Pathological myopia    | 0.9     | 0.3      |
| 11            | 20/M | Pathological myopia    | 0.3     | 0.15     |
| 12            | 55/M | Diabetic retinopathy  | 0.9     | 0.6      |
| 13            | 55/M | Diabetic retinopathy  | 0.9     | 0.6      |
| 14            | 49/M | Diabetic retinopathy  | 0.6     | 0.3      |
| 15            | 52/M | Macular degeneration  | 0.3     | 0.15     |
| 16            | 52/M | Macular degeneration  | 0.3     | 0.15     |
| 17            | 62/M | Dry ARMD              | 0.9     | 0.6      |
| 18            | 60/F | Dry ARMD              | 0.15    | 0        |
| 19            | 20/M | Macular degeneration  | 0.15    | 0        |
| 20            | 20/M | Macular degeneration  | 0.15    | 0        |
| 21            | 51/M | Vitritis               | 0.9     | 0.75     |

Discussion

An absorptive lens is designed to absorb a specific range or proportion of incident radiation.[8] As the eye is most sensitive to wavelengths in the region of 555 nm (the yellow-green portion of the spectrum); thus, yellow glasses are recommended for an improvement in CS. The yellow filters cut opponent blue light;[9] reduce the scatter within the ocular media; and decrease glare, chromatic aberrations, and recovery time of changes in light adaptation.[8] It is also claimed that such glasses improve VA.[6,10] With use of photography technique, Zigman et al.[11] showed that filtering out light wavelengths shorter than 480 nm improved image quality.

In this study, we utilized yellow-amber NoIR glasses, which absorb high-energy short wavelengths (up to 400 nm) as well as infrared rays. The NoIR series cools the light by reducing the sun’s heat energy, thus soothing and comforting the entire viewing experience. This is the first study on NoIR filters which filter two types of wavelength; earlier studies utilized filters which obstruct only one type of wavelength.[1-6,8-12]

The cones can detect 0.5%, contrast whereas rods need a minimum contrast of 5% to be detected. The retinal ganglion cells deliver response amplitude. Our subjects showed lower values for CS as they had photoreceptors and ganglion cells affection from retinal diseases.

In previous studies on subjects having retinal affection, log values of Pelli Robson CS and BCVA, respectively, were found to be 1.65 and 0.2 (6/9.5; 20/32) in subjects of dry ARMD[13]; 1.32 ± 0.20 and 0.063 ± 0.14 (6/6; 20/20) in subjects of type 2 diabetes[14]; and 0.95 and 0.6–0.9 (20/80 to 20/160) in subjects having variable retinal diseases.[8] The baseline CS value in our subjects (0.52 ± 0.29) was below the normal range 1.68–1.84.[15] None of our subject had CS values above 0.9 before or after wearing yellow-amber NoIR glasses. The mean distance BCVA was logmar 0.68 (about 20/80; 6/24) and mean near BCVA was logmar 0.72 (about 20/100; 6/30). Thus, CS and BCVA of our subjects were lesser than the subjects of earlier studies.

Variable results for a change in CS and BCVA have been seen with filters. Mahjoob et al. and Ahmad et al. found a significant improvement in CS with yellow filter.[8,10] In 15 retinitis pigmentosa subjects, Carracedo et al.[2] found an 11–43% increase in BCVA, a 27–34% increase in CS with yellow filters. Albarran et al.[1] noticed no improvement in CS with use of seven different color lenses which had a clear center and tinted periphery, as CS is primarily carried through central vision. Lavric and Pompe[14] found that a significant improvement in VA (P = 0.05) but not in CS (P = 0.94) with blue-filtering lenses. They explained that yellow chromophores in these lenses filtered the blue light (380–500 nm), while factually photopic CS gets modified only by filtering wavelengths between 500 and 600 nm. Eperjesi and Agelis[10] saw a decline in VA and CS with Corning photochromic filter, including CPF450, CPF511, and CPF527 and authors attributed this to a reduction in retinal illumination caused by filters. We feel this happened as CPF filters transmit selective wavelengths corresponding to their number, but do not transmit wavelength of 555 nm, which
is most sensitizing to the eye. In our study subjects, baseline CS varied from 0.3 to 0.9 (mean value 0.52 ± 0.29), while CS after wearing of yellow-amber NoIR glasses varied from 0 to 0.9 (mean value 0.52 ± 0.28). There was a mean reduction of 0.002 ± 0.24 in CS post-LVA ($P = 0.909$; NSS). Our subjects had a mean distance BCVA of Logmar 0.68 ± 0.17 (about 20/80; 6/24) and mean near BCVA of Logmar 0.72 ± 0.25 (about 20/100; 6/30). We feel that poor VA of our subjects indicated a more severe disease of photoreceptors and ganglion cells and this impeded improvement in CS with use of filters [Table 4]. We did not study the change of BCVA in our subjects following application of yellow amber NoIR glasses.

While the authors like Muller et al.,[18] Gella et al.,[12] Carracedo et al.,[8] Lavrie and Pompe,[4] and Rosenblum et al.[3] noticed concurrent improvement in CS and VA with filters; a positive correlation between an improvement in CS and VA was noticed by Muller et al. and Gella et al.[12,13] Though we did not examine distance and near BCVA post use of yellow amber glasses, through statistical analysis a positive correlation between CS with both distance BCVA and near BCVA was found. A correlation between CS and near BCVA has been studied for the first time. This shows that filters will enable better contrast for near tasks also.

The effect of filters in relation to a particular retinal disease has been rarely found. Pathai et al.[7] found lower CS score in the presence of thin temporal RNFL and Ahmad et al.[8] failed to see an improvement of CS with filters in subjects who had albinism or Stargardt’s disease. As compared to previous studies, our cohort had the largest number of subjects. The strength of our study was that we examined effect of filters in various retinal diseases and different types of macular affections. We found that the presence of diseases like pathological myopia, diabetic retinopathy, macular diseases, open-angle glaucoma, dry ARMD (age-related macular degeneration), wet ARMD, and vitritis caused a reduction in CS in 16 of our subjects after the application of a filter [Table 1]. In our subjects, the presence/absence of macular OCT features like subretinal fluid, macular scar, pigment epithelial detachment, drusens, epiretinal membrane, exudates, choroidal neovascular membrane, vitreomacular traction, and lamellar macular hole did not significantly influence CS values both at pre-LVA and post-LVA stage [Table 3]. This implies that though our subjects had different types of macular involvements but magnitude of retinal affection was similar, such that one particular type of macular feature did not affect CS in a manner different than the presence of another type of macular affection. Nixon and Flinn found that reducing diabetic macular edema improved both CS and BCVA.[14] Unlike Nixon and Flinn, we did not treat these diseases to look for an the improvement in CS.

The yellow filters are supposed to be good for macular health as they obstruct phototoxic blue light.[8] Eperjesi et al.[9]
Table 4: Effect of filters on CS and BCVA

| Authors                        | Filter                                         | Improvement in CS                      | Improvement in BCVA with application of filter |
|--------------------------------|------------------------------------------------|----------------------------------------|-----------------------------------------------|
| 1. Carracedo et al.[2]         | MaxSight Amber contact lens and CSF-Coming 527 glasses filter | Yes; SS                               | Yes; NSS                                      |
| 2. Rosenblum et al.[3]         | Yellow, amber and orange filters               | 27–34% increase                       | 11-43% increase                               |
| 3. Albarran et al.[1]          | Seven different color lenses                   | No                                     | Did not study                                 |
| 4. Lavric and Pompe[4]         | Blue filters                                   | Yes; NSS                               | Yes; SS                                       |
| 5. Eperjesi and Agelis[6]      | Corning photochromic filter including CPF450, CPF511, and CPF527 | No (decline seen)                      | No (decline seen)                            |
| 6. Ahmad et al.[8]             | Yellow filter                                  | Yes; SS (No improvement in Albinism and Stargardt’s disease) | Did not study                                |
| 7. Mahjoob et al.[10]          | Yellow filter                                  | Yes                                    | Did not study                                 |
| 8. Zigman et al.[11]           | Short wavelength filters                       | Yes                                    | Not applicable                                |
| 7. Our study                   | Yellow-amber NoIR filter                       | No                                     | Did not study; studied correlation values      |

concluded that previous authors provided very little objective evidence to support improvements in visual performance in terms of CS and VA with yellow filters. From a systematic review of 51 randomized control trials from 17 countries, Downie et al.[3] concluded that blue-filtering lenses did not have a clinically meaningful effect on BCVA and CS. Therefore, the use of tinted lenses in LV remains controversial. We recommend further studies for an improvement in CS with this yellow NoIR filter.

**Conclusion**

From our study, we conclude that retinal diseases affect functioning of photoreceptors and ganglion cells causing a simultaneous reduction in different visual functions carried by these cells including CS and VA. Both these parameters get affected in a similar manner and reduced VA would imply poorer response to filters for improving CS. Though retinal diseases and type of macular involvement in these retinal diseases may be variable, it is the magnitude of retinal affection which finally determines response to treatment for improving CS. Yellow filters are recommended for LV subjects as they improve both CS and VA.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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