

Assessing the Effect of Colored Filters on Glare Sensitivity of Post Refractive Surgery Patients

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Abstract

Purpose: The use of colored filters is one recommended way for patients to reduce glare. This study assessed the effect of colored filters for reducing glare symptoms in post refractive surgery patients.

Method: Log MAR visual acuity was determined in 70 participants (140 eyes) who had undergone PRK refractive surgery using three colored filters (Yellow, Green, and Red) in different light conditions.

Results: Measured visual acuity was significantly reduced with red and green filters in glare and nonglare conditions when compared to its measurement without a filter. An asymmetrical light condition also revealed a significant difference in the visual acuity of the right and left eye when compared to each other. However, no significant differences were observed for the yellow filter in either the measured visual acuity of each eye in both light conditions or of the right and left eyes compared to each other.

Conclusion: Red and green filters are poor choices for reducing glare in post refractive surgery patients but a yellow filter could be used to decrease glare and improve acuity. (*Eye Science* 2013; 28:171–175)

Keywords: glare; colored filters; refractive surgery

Introduction

The refractive surgeries conducted today leave

most people satisfied with their operation and their vision, but some patients are still dissatisfied with symptoms such as glare¹⁻⁴. Glare problems are not an issue in normal people because of their normal optical conditions, but the optical changes occurring in the cornea after refractive surgery create a different condition^{1, 2, 5}.

Many solutions have been presented to decrease this visual disorder in different lighting, including improving surgical procedures^{1, 6}. One nonsurgical method for decreasing glare in these patients is prescription of colored filters⁷⁻¹¹. Different studies have reported that colored filters can change visual function, so changing the visual spectrum with different filters has been hypothesized to influence visual resolution and the glare response¹². This method has shown considerable variation and contradiction because of differences in measuring methods and the use of colored lenses of various densities¹²⁻¹⁵.

Many methods are available to test glare, but it seems that tests that can quantify the changes in visual acuity could be more compatible with common findings of clinical examinations. Assessing the results of contrast sensitivity and glare disability cannot be used as criteria of visual acuity changes in term of Snellen or other similar units¹⁶. Therefore, in the present study, we measured the effects of the use of colored filters on a subject's visual acuity changes after PRK refractive surgery by using a visual acuity ETDRS chart, with and without glare. We expected that this method would provide more appropriate clinical patterns to show the influence of colored filters on visual acuity.

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Materials and methods

This study was conducted on subjects who had undergone PRK refractive surgery at a specialized eye center. At least three months and at most eleven months had passed since their surgeries.

The following were the input criteria for inclusion in this study:

Not having another operation in their eyes.

Having a suitable tear film.

Residual refractive errors as follows; the amount of spherical hyperopia less than +1.00 Diopter and with no spherical myopia, the amount of with the rule astigmatism less than -0.75 and against the rule and oblique astigmatism less than -0.25 Diopter. The main point for these subjects was that they have a visual acuity of 10/10 or better.

Measuring procedure

All patients were examined in a specific place. The visual acuity of the participants in their examinations before operation was evaluated by Snellen chart but in their examinations after operation, this was measured by ETDRS chart [Nidek chart, projector/cp_770]. Measurements were obtained at a standard distance and in standard light conditions (BS4274) and examinations were also done in one eye and by using a trial frame. Levels of this study included the following points:

At first, the visual acuity of every person was evaluated by ETDRS chart in stable light conditions. Measurement was then repeated after random placement of yellow, green, or red filters in front of the patient's eyes. The final visual acuity of this chart was according to log MAR. At the next level, an asymmetrical light condition was created using a halogen light source on the left side of the patient (at a distance of about 40 cm from the left eye and about 46 cm from the right eye); this created a light intensity of about 95 LUX in the left eye and 35 LUX in the right eye. The visual acuity of every person was again randomly evaluated using the yellow, green, or red filters. The results were classified using descriptive statistics and compared using a *t*-test. All subjects participated in this study voluntarily and with personal satisfaction.

Results

This study evaluated 70 people (140 eyes); 80 percent were woman. Their average age was 26.2 years, with standard deviation ± 3.76 (from 19 to 34 years).

The mean visual acuity in each eye with green and red filters under glare conditions was statistically different from the mean of visual acuity without filters as determined by the *t*-test ($P < 0.0001$). The mean of visual acuity of the right and left eyes under these same conditions (red or green filter and glare) also showed a significant difference ($P < 0.0001$). However, the use of the yellow filter resulted in no statistically significant differences either when comparing acuity without the filter ($P > 0.05$) or comparing the acuity in the right and left eyes ($P > 0.05$).

However, in the light condition without glare, the mean of visual acuity in each eye was significantly higher with the green and red filters than without the yellow filters ($P < 0.0001$). In contrast, the mean of visual acuity showed no statistically significant difference with the yellow filter or without it ($P > 0.05$). The mean of visual acuity in the right eye was about 0.026 log MAR better with the yellow filter than without the filter ($P > 0.05$).

Discussion

Currently, many studies have focused on the impact of filters on visual function and glare response. For example, Mehta¹⁷ evaluated the impact of colored lenses on stereopsis in different light conditions and Lee⁸ evaluated the impact of colored lenses on contrast sensitivity. Clark's study in 1969 showed the impact of colored lenses on improvement of glare¹⁰. Visual acuity includes the greatest level of visual function and it is a common clinical criterion that depends on different factors. Ultimately, visual acuity is dependent on the optical and neurological function of eye^{18,19}, so the present study focused on the impact of yellow, green and red filters on the visual acuity of people who had undergone refractive surgery, evaluated by ETDRS chart under different light conditions. Among these three filters (all had a similar optical density), the measured visual acuity

with green and red filters with or without glare in each eye was poorer than its measurements without the filter ($P < 0.0001$), which was a considerable finding from a clinical point of view. These results were similar to those reported by Dolores²⁰. The measured visual acuity with yellow filter with and without glare in each eye was close to its measurement without the filter, which was compatible with the results of studies of Yoshimitsu⁹ and Kuyk²¹.

From a physiological perspective, the retinocortical nerves are divided into three main parallel pathways containing neurons that show different sensitivity to color, spatial, and time frequencies^{22,23}. The color information about green and red is processed and transferred by parvo neurons while the color information about yellow and blue seems to be transferred by the konio pathway²⁴⁻²⁶. Unlike the parvo and konio cells, the magno neurons show a weak color-

opponency. In other words, the magno neurons have an equal luminous efficiency in the center and surrounding and in fact they are monochromatic²⁷⁻²⁹. The parvo pathway plays a more important role in color discrimination and visual acuity, while the magno system plays more of a role in movement and low spatial frequencies. In most similar studies^{9,12-15}, the visual function was examined in both eyes or in the dominant eye and in general, in considering the result, if the intervention was the same for each eye, the results for the right and left eyes were considered together. In the present study, the glare source was asymmetric for each eye and some measurements showed a meaningful difference between the two eyes (Tables 1,2). Therefore, the measurements for each eye were considered separately.

No broad studies have examined the functional differences in retinocortical pathways in the right and

Table 1 Descriptive statistics for visual acuity with and without three colored filters (yellow, green, and red by ETDRS chart) under conditions with and without glare

Visual acuity ETDRS (logMAR)	Mean	Standard deviation	Minimum	Maximum
With Glare OD	0.01	0.07	-0.10	0.24
Without Glare OD	0.03	0.08	-0.10	0.32
With Glare with RED Filter OD	0.15	0.10	-0.04	0.42
Without Glare with RED Filter OD	0.16	0.11	-0.06	0.42
With Glare with GREEN Filter OD	0.06	0.08	-0.08	0.30
Without Glare with GREEN Filter OD	0.09	0.09	-0.08	0.32
With Glare with YELLOW Filter OD	0.00	0.07	-0.19	0.20
Without Glare with YELLOW Filter OD	0.01	0.08	-0.12	0.21
With Glare OS	0.00	0.07	-0.10	0.24
Without Glare OS	0.02	0.07	-0.10	0.22
With Glare with RED Filter OS	0.23	0.12	0.00	0.49
Without Glare with RED Filter OS	0.16	0.10	-0.02	0.42
With Glare with GREEN Filter OS	0.11	0.10	-0.04	0.44
Without Glare with GREEN Filter OS	0.09	0.09	-0.06	0.34
With Glare with YELLOW Filter OS	0.01	0.08	-0.10	0.40
Without Glare with YELLOW Filter OS	0.02	0.07	-0.10	0.22

Table 2 Comparison of the means of the measured visual acuity under different filter and lighting conditions

Condition	P-value
With glare OD vs. With glare with Yellow filter OD	0.058
With glare OS vs. With glare with Yellow filter OS	0.216
Without glare OS vs. Without glare with Yellow filter OS	0.433
With glare OD vs. With glare OS	0.448
With glare with Yellow filter OD vs. With glare with Yellow filter OS	0.217
Without glare OD vs. Without glare OS	0.233
Without glare with Red filter OD -Without glare with Red filter OS	0.770
Without glare with Green filter OD vs. Without glare with Green filter OS	0.645
Without glare with Yellow filter OD vs. Without glare with Yellow filter OS	0.480

left eyes, but the present study suggests that before placing the filter, the visual acuity of the right and left eyes, with and without glare, was not significantly different ($P < 0.005$) (Table 2). However, after placing the red or green filters, the responses of each eye showed a meaningful difference in the asymmetric light condition ($P < 0.0001$) (Table 1), which suggests that the sense factor of eye dominance is related to this difference³⁰. The results of the t-test in most cases indicated that the visual acuity of the left eye was worse than the right eye (for example, the visual acuity was worse in the left eye than in the right eye under the glare condition with all three colored filters) (Table 1). Most people are right eye dominant³⁰⁻³², so we can say that patients showed a better visual acuity with some filters in the right eye in comparison with the left eye. These differences in the visual acuity in the right and left eyes indicate the necessity of doing further research based on differences in density between right and left eye filters.

The measured visual acuity decreased under glare conditions. This result for the green and red filters could be related to luminance efficiency function, where the peak of the luminous efficiency of the human eye in photopic condition is about 555 nm.

The response to the yellow filter was different from that seen for the green and red filter. The measured visual acuity remained the same as the normal condition in each eye with the yellow filter with or without glare ($P > 0.05$) (Table 2), in agreement with previous studies that have shown a positive effect of yellow filters on visual function^{7,14,33-37}. A yellow filter with this specification (cut off transmittance: 600 ± 50 nm) is recommended for people who have had refractive surgery and are dissatisfied with glare symptoms. The green and red filters caused a difference in visual acuity between the two eyes and considerably decreased visual acuity in clinical examination, so they are not recommended as appropriate filters.

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References

1 Fan-Paul NI, Li J, Miller JS, et al. Night vision distur-

- bances after corneal refractive surgery. *Surv Ophthalmol*, 2002, 47:533-546.
- 2 Hersh PS, Steinert RF, Brint SF. Photorefractive keratectomy versus laser in situ keratomileusis: Comparison of optical side effects. *Ophthalmology*, 2000, 107:925-933.
- 3 Boxer Wachler BS, Durrie DS, Assil KK, et al. Improvement of visual function with glare testing after photorefractive keratectomy and radial keratotomy. *Am J Ophthalmol*, 1999, 128:582-587.
- 4 Lee YC, Hu FR, Wang IJ. Quality of vision after laser in situ keratomileusis: Influence of dioptric correction and pupil size on visual function. *J Cataract Refract Surg*, 2003, 29:769-777.
- 5 Mrochen M, Kaemmerer M, Mierdel P, et al. Increased higher-order optical aberrations after laser refractive surgery: A problem of subclinical decentration. *J Cataract Refract Surg*, 2001, 27:362-369.
- 6 Alio JL, Pinero D, Muftuoglu O. Corneal wavefront-guided retreatment for significant night vision symptoms after myopic laser refractive surgery. *Am J Ophthalmol*, 2008, 145:65-74.
- 7 Perez MJ, Sanchez C, Puell C, et al. Effect of yellow filter on mesopic contrast threshold with and without glare in myopia corrected by laser in situ keratomileusis (Lasik). *Invest Ophthalmol Vis Sci*, 2003, 44:2773-B612.
- 8 Lee JE, Stein JJ, Prevost MB, et al. Effect of variable tinted spectacle lenses on visual performance in control subjects. *CLAO Journal*, 2002, 28:80-82.
- 9 Kohmura Y, Murakami S, Aoki K. Effect of yellow-tinted lenses on visual attributes related to sports activities. *J Hum Kinet*, 2013, 36:27-36.
- 10 Clark BA. Color in sunglass lenses. *Am J Optom Arch Am Acad Optom*, 1969, 46:825-840.
- 11 Elliott DB. Contrast sensitivity and glare testing. In: Borish's Clinical Refraction, Second Edition. (Patricia C. Daniel J. Benjamin), Elsevier Inc: Philadelphia, Copyright 2006, 1998, pp: 271-288.
- 12 Shi W, Lockhart TE, Arbab M. Tinted windshield and its effects on aging drivers' visual acuity and glare response. *Saf Sci*, 2008, 46:1223-1233.
- 13 Eperjesi F, Agelis LE. Effects of yellow filters on visual acuity, contrast sensitivity and reading under conditions of forward light scatter. *Graefes Arch Clin Exp Ophthalmol*, 2011, 249:709-714.
- 14 Wolffsohn JS, Cochrane AL, Khoo H, et al. Contrast is enhanced by yellow lenses because of selective reduction of short-wavelength light. *Optom Vis Sci*, 2000, 77:73-81.
- 15 Subramanian PS, O'Kane B, Stefanik R, et al. Visual performance with night vision goggles after photorefractive keratectomy for myopia. *Ophthalmology*, 2003, 110:525-

- 530.
- 16 Haw W, Manche E. Visual performance following photo astigmatic refractive keratectomy: A prospective long-term study. *J cataract Refract Surg*, 2000, 26: 1463–1472.
 - 17 Mehta M, Ramkissoon P, Bhagwanjee AM. A comparison of the effect of reduced illumination and tinted lenses on stereopsis at near. *S Afr Optom*, 2007, 66: 3 – 11.
 - 18 Schwarts SH. In: *Visual perception (A clinical orientation) Fourth Edition*, McGraw –Hill Medical, Inc: New York, Copyright e 2010, 2004, PP: 169–199.
 - 19 Neil CW. Visual performance. In: *Optometry science techniques and clinical management (Second Edition)*. (Rosen field M, Logan N and Edwards K), Elsevier Ltd: New York, First edition 1988, Second edition 2009, PP: 69–76.
 - 20 de Fez D, Luque J, Viqueira V. Enhancement of contrast sensitivity and losses of chromatic discrimination with tinted lenses. *Optom Vis Sci* 2002; 79: 590–597.
 - 21 Kuyk TK, Garcia PV, McLin LN, Kent JF. Effects of colored filters on visual function. Final technical rept: May 2008.
 - 22 Lennie P, Krauskopf J, Sclar G. Chromatic mechanisms in striate cortex of macaque. *J Neurosci* 1990; 10: 649–669.
 - 23 Schiller PH, Malpeli JG. Functional specificity of lateral geniculate nucleus lamina of the rhesus monkey. *J Neurophysiol*, 1978, 41: 788–797.
 - 24 De Valois RL, Abramov I, Jacobs GH. Analysis of response patterns of LGN cells. *J Opt Soc Am*, 1966, 56: 966–977.
 - 25 Wiesel TN, Hubel DH. Spatial and chromatic interactions in the lateral geniculate body of the rhesus monkey. *J Neurophysiol*, 1966, 29: 1115–1156.
 - 26 Ts'o DY, Gilbert CD. The organization of chromatic and spatial interactions in the primate striate cortex. *J Neurosci*, 1988, 8: 1712–1727.
 - 27 Lee B.B., Sun H. The physiological origin of chromatic response components in signals of the magnocellular pathway of the macaque. *Invest Ophthalmol Vis Sci*, 2003, 44: E–Abstract 3250.
 - 28 Livingstone MS, Hubel DH. Psychophysical evidence for separate channels for the perception of form, color, movement, and depth. *J Neurosci*, 1987, 7: 3416–3468.
 - 29 Livingstone M, Hubel D. Segregation of form, color, movement, and depth: anatomy, physiology, and perception. *Science*, 1988; 240: 740–749.
 - 30 Railo H, Tallus J, Hamalainen H. Right visual field advantage for perceived contrast: Correlation with an auditory bias and handedness. *Brain Cogn*, 2011, 77: 391–400.
 - 31 Samarawickrama C, Wang JJ, Huynh SC, et al. Macular thickness, retinal thickness, and optic disk parameters in dominant compared with non-dominant eyes. *J AAPOS*, 2009, 13: 142–147.
 - 32 Gur RE, Gur RC. Sex differences in the relations among handedness, sighting-dominance and eye-acuity. *Neuropsychologia*, 1977, 15: 585–590.
 - 33 Yap M. The effect of a yellow filter on contrast sensitivity. *Ophthalmic Physiol Opt*, 1984, 4: 227–232.
 - 34 Hovis JK, Lovasik JV, Cullen AP, et al. Physical characteristics and perceptual effects of “blue-blocking” lenses. *Optom Vis Sci*, 1989, 66: 682–689.
 - 35 Zigman S. Vision enhancement using a short wavelength light-absorbing filter. *Optom Vis Sci*, 1990, 67: 100–104.
 - 36 Kelly SA, Goldberg SE, Banton TA. Effect of yellow-tinted lenses on contrast sensitivity. *Am J Optom Physiol Opt*, 1984, 61: 657–662.
 - 37 Kinney JA, Schlichting CL, Neri DF, et al. Reaction time to spatial frequencies using yellow and luminance-matched neutral goggles. *Am J Optom Physiol Opt*, 1983, 60: 132–138.