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Effect of Tinted Lenses on Near Contrast Sensitivity

Vaishali Dodah and Azam Nur Hazman Bin Azmi*

Faculty of Optometry and Vision Sciences, SEGi University, Kota Damansara, Malaysia

Abstract

Tinted lenses are known to influence contrast sensitivity by interfering with light transmission. The aim of this study was to investigate the effect of different gradings of grey tinted lenses such as 15% and 25% on near contrast sensitivity. Forty-four healthy individuals including sixteen males and twenty-eight females participated in this study. The mean age was 22.09 ± 1.84 years with mean spherical equivalent of -2.22 ± 1.71D. Contrast sensitivity was measured by using near FACT chart with only 6cpd spatial frequency was measured. The mean contrast sensitivity without any tinted lenses, with 15% and 25% grey tinted lenses was 2.03 ± 0.13, 2.08 ± 0.11 and 1.96 ± 0.15 respectively. Repeated measures ANOVA showed that there was a statistically significant difference in contrast sensitivity without any tinted lenses and with the different gradings of grey tinted lenses, $F(1.74, 74.74) = 26.25$, $p < 0.001$. In this study, it could be noted that contrast sensitivity at 6cpd was higher with the 15% tinted lens followed by the habitual state and a reduction was also found with the 25% tinted lens. Therefore, to conclude, it is of utmost importance to consider the spatial aspects of tasks and the effect of tints on contrast sensitivity before prescribing them.

Keywords: Grey tinted lenses; Near contrast sensitivity

Introduction

Tinted spectacles lenses are specially designed lenses that filter light at a specific wavelength [1]. These lenses work by minimizing the transmission of light [2]. The usage of tinted lenses is increasing nowadays and this must not result in deteriorating the visual performance such as visual acuity and contrast sensitivity [3]. Tinted spectacles lenses are dispensed by optometrists for several reasons such as to provide protection against the harmful ultraviolet-rays, to cut off excessive amount of glare, to lower the scattering of light in some ocular disorders namely retinitis pigmentosa, albinism and cataracts, to provide better cosmetic appearance in strabismic patients, and also to ameliorate colour discrimination in colour vision deficiency patients [4]. Besides, tinted lenses were primarily designed to enhance productiveness at workplace by minimizing headaches and eyestrain caused under fluorescent lighting condition. Tinted lenses are also proved to be beneficial in cases of migraines, cone dystrophies, traumatic brain injury, severe dry eyes, and other ocular pathologies that are known to induce photophobia [1]. Apart from the conventional tinted lenses available in the market such as grey, brown and green, other available colours such as purple, blue, and yellow are in demand [3].

Contrast sensitivity, which is an important attribute of vision, is defined as the capability to distinguish differences in brightness between adjacent areas [5]. Contrast sensitivity is affected by various factors such as increasing age, pupil diameter, refractive error especially hyperopia, and under photopic conditions in individuals without any ocular and systemic diseases [6]. High myopic individuals with greater than -6D, have remarkably loss in contrast sensitivity as there is a decline in high spatial frequencies [7]. In contact lens wearers, presence of uncorrected residual astigmatism and deposits can affect contrast sensitivity at higher spatial frequencies. Furthermore, low tear break-up time lesser than five seconds leads to worse contrast sensitivity [8]. Moreover, a decrease in contrast sensitivity is the result of central superficial punctate keratopathy in dry eye patients [9].

Tinted lenses are known to enhance the contrast sensitivity due to the fact that these lenses reduce the transmission of light, thereby decreasing glare and increasing the visibility of the objects to be viewed. Lighter tints improve contrast sensitivity at middle that is 6cpd to high spatial frequencies such as 12 and 18cpd whereas darker tints enhance contrast sensitivity at low spatial frequencies that is 1.5 and 3cpd. Retinal illumination is reduced further with darker tints compared to lighter tints. Therefore, darker tints yield in decrement of contrast sensitivity at middle to high spatial frequencies [2]. Moreover, according to Shaik et al., darker tints are associated with pupil dilation which causes aberrations and thus reducing contrast sensitivity [2]. Lighter tints have lesser impact in the retinal illumination and also there is no notable change in the pupil size when compared to darker tints. For this reason, lighter tints contribute to better contrast sensitivity function at middle to high spatial frequencies. The spatial frequencies are affected in a different manner by different grades of tints.

Therefore, as mentioned earlier, according to Raabe, Kini, and Lee tinted lenses were primarily designed to enhance productiveness at workplace by minimizing headaches and eyestrain caused under fluorescent lighting condition, the main objective of our study was to investigate the effect of different gradings of grey tinted lenses such as 15% and 25% on near contrast sensitivity which represents the contrast sensitivity in indoor setting [1].

Materials and Methods

The study was carried out in Binocular Vision/Pediatrics Clinic Room 2, Faculty of Optometry & Vision Sciences, SEGi University, Kota Damansara. A total of 44 healthy subjects with the mean age of 22.09 ± 1.84 years participated in this study whereby 16 were male and 28 were female. The subjects included in the study were between 19 to

***Corresponding author:** Azam Nur Hazman Bin Azmi, Faculty of Optometry and Vision Sciences, SEGi University, Kota Damansara, Malaysia, E-mail: azam@segi.edu.my, azam@segi.edu.my

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29 years old, emmetropes and myopes up to -6.00 DS with astigmatism less than -1.00DC and visual acuity 6/6 or better at distance and N5 at near, with no ocular pathology or surgery and tear break-up time of more than five seconds. Individuals who did not meet the inclusion criteria including contact lens wearers were excluded from the study. Moreover, fundus photo was taken for myopic subjects more than -4.00DS by using COBRA HD fundus camera (CSO, Scandicci, Firenze, Italy). In addition, before proceeding with the study, the consent of the subjects was obtained and instructions about the procedures were given to them. Contrast sensitivity was measured by using a near FACT chart placed at 46cm on a scaled rod and only 6cpd spatial frequency was measured. Near contrast sensitivity measurement with the habitual state was taken first, then the total number of subjects was randomly divided into 2 groups namely A and B. The near contrast sensitivity of group A was recorded first with a 15% grey tinted lens (HOYA True Grey Natural F-15F) as shown in Figure 1 and then measurement for group B was taken with a 25% grey tinted lens (HOYA True Grey Rich F-25F) as shown in Figure 2. The measurement was then repeated with 25% and 15% tinted lens for group A and B respectively in order to prevent biasness of results. The subjects had to answer by identifying the direction of the gratings that is left, right, or straight (up) found in Row C (6cpd) which consisted of 9 columns in the FACT chart until they were not able to appreciate the orientation of the gradings. A trial frame was used which consisted of the subject's current prescription as obtained in the preliminary assessment and the tinted lenses were placed on the trial frame itself. Only the right eye for all the subjects was tested in the study.

Results

In total, 44 subjects were selected for this study with a mean age of 22.09 ± 1.84 years. Out of the 44 subjects, 16 were male (36%) and 28 were female (64%) as shown in Figure 3. The mean spherical equivalent was found out to be -2.22 ± 1.71D and the mean tear break-up time (TBUT) was 7.41 ± 0.79 seconds.

Table 1 illustrates the mean and standard deviation of the log score for the contrast sensitivity measurement without tinted lenses, with 15% and 25% tinted lenses. It could be found that the mean log score for contrast sensitivity measurement without tinted lenses was 2.03 ± 0.13, while the mean value of the log score for the 15% and 25% tinted lenses were 2.08 ± 0.11 and 1.96 ± 0.15 respectively.

Figure 1: HOYA True Grey Natural F (15F) plano lens.

Figure 2: HOYA True Grey Rich F (25F) plano lens.

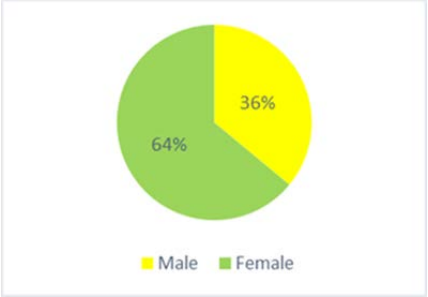

Figure 3: Gender distribution.

Table 1: Mean and SD of contrast sensitivity.

Study lenses	Log contrast sensitivity score Mean ± SD
Without tinted lenses	2.03 ± 0.13
15% grey tinted lens	2.08 ± 0.11
25% grey tinted lens	1.96 ± 0.15

Table 2: Test of normality using Shapiro-Wilk test.

Contrast sensitivity	Shapiro-Wilk test (Significance)
Without tinted lenses	<0.001
With 15% tinted lens	<0.001
With 25% tinted lens	<0.001

Table 3: Test of normality using skewness method.

Contrast sensitivity	Skewness (Statistic)	Std. Error (Mean)	Data normality (Conclusion)
Without tinted lenses	-0.424	0.020	Not normal
With 15% tinted lens	-0.279	0.016	Not normal
With 25% tinted lens	-0.953	0.023	Not normal

Table 2 shows the test of normality for the log contrast sensitivity score without tinted lenses, with 15% and 25% tinted lenses respectively, whereby, it could be noted that by using the Shapiro-Wilk test as the sample size was less than 50, the data was not normal because the sig. value was less than 0.05 ($p < 0.05$). Hence, the skewness method was used to check for the normality of data.

Table 3 represents the normality test for contrast sensitivity by the skewness method, and it was deduced that the data was not normal as the skewness (statistic) values of the score without tinted lenses, with 15% and 25% tinted lenses were outside the range of twice the standard error. Therefore, the standard deviation method was evaluated to check for normality of data.

Table 4 displays the normality test for contrast sensitivity by using the standard deviation method, and it was found that the data was normal as the values obtained for contrast sensitivity without tinted lenses, with 15% and 25% tinted lenses were less than 30% by using the formula stated in Table 4. Therefore, the distribution of data was considered normal based on standard deviation method.

Table 5 depicts the Mauchly's test of sphericity, whereby, it was noted that the test was statistically significant (W = 0.808, sig. 0.011) indicating that the sphericity assumption was not met.

Therefore, the Huynh-Felt correction was employed in the repeated measures ANOVA. It revealed that there was a statistically significant

Table 4: Test of normality using standard deviation method.

Contrast sensitivity	Standard deviation (SD)	Mean	(SD / Mean X 100%)
Without tinted lenses	0.13	2.03	6.40 %
With 15% tinted lens	0.11	2.08	5.29 %
With 25% tinted lens	0.15	1.96	7.65 %

Table 5: Mauchly's test of sphericity.

Mauchly's test of sphericity		
Within Subjects Effects	Mauchly's W	Sig.
Contrast sensitivity	0.808	0.011

Table 6: Estimated Marginal means.

Contrast Sensitivity	Mean	Std. Error
Without tinted lenses	2.03	0.019
With 15% tinted lens	2.08	0.016
With 25% tinted lens	1.96	0.023

Table 7: Repeated Measures ANOVA: Pairwise comparisons with significance values and mean differences of contrast sensitivity without tinted lenses and with 15% and 25% tinted lenses.

Repeated Measures ANOVA (Pairwise comparisons)			
Contrast sensitivity		**Significance (p)**	**Mean difference**
Without tinted lenses	With 15% tinted lens	0.001	-0.052
	With 25% tinted lens	0.001	0.074
With 15% tinted lens	With 25% tinted lens	<0.001	0.126

difference in contrast sensitivity without tinted lenses and with the different levels of grey tints used in our study, $F(1.74, 74.74) = 26.25$, $p<0.001$.

Table 6 and 7 represents the estimated marginal means and the pairwise comparisons respectively. The results of the pairwise comparison is based on the estimated marginal means between without tinted lenses and with different levels of grey tinted lenses that is 15% and 25% tinted lenses. It could be deduced that there was a statistically significant difference among all of them especially the contrast sensitivity score between 15% and 25% tinted lenses (Table 7).

The mean contrast sensitivity score with 25% tinted lens ($M = 1.96$, $SD = 0.15$) was found out to be lower than the mean contrast sensitivity score without tinted lenses ($M = 2.03$, $SD = 0.13$) and mean contrast sensitivity score with 15% tinted lens ($M = 2.08$, $SD = 0.11$).

Discussion

Contrast sensitivity is an important visual function which can be easily affected by various factors including tinted lenses. This study was carried out by using different levels of grey tinted lenses consisting of 15% and 25% tint whereby the aim was to observe the effect of these tinted lenses on the near contrast sensitivity.

This study was conducted by using the near FACT chart and 6cpd spatial frequency was measured under standard lighting condition. The results obtained revealed that there was a statistically significant difference in the contrast sensitivity measurement under different levels of grey tinted lenses. The reason of the significant difference obtained could be due to the fact that tinted lenses interfere with light transmission depending on the grading of the tints thus affecting the contrast sensitivity. The contrast sensitivity was found out to be lower with the 25% tinted lens compared with 15% tinted lens and without any tinted lenses.

Our study revealed an improvement in contrast sensitivity with 15% grey tinted lenses when compared to the habitual state. According to Shaik et al., (2013) a study was conducted to study the effect of tinted spectacles lenses on contrast sensitivity [2]. There was an improvement in low to middle spatial frequencies with lighter tints including grey tinted lenses which had 85% and 75% light transmission that is 15% and 25% tinted lenses. In addition, the study was conducted by using the FACT chart at 3m distance and all the spatial frequencies were evaluated. It could be found that at 6cpd, without tinted lenses and with the 15% and 25% grey tinted lenses at 3m, the mean contrast sensitivity was found out to be 1.85, 1.91 and 1.89 respectively indicating that there was a higher improvement in contrast sensitivity with the tinted lenses compared to the habitual state. This is because tinted lenses are capable of reducing glare from reflective surfaces. As a result of reducing the glare, there is an increase in the visibility of the objects on a surface, thereby enhancing the contrast sensitivity. Thus, this was observed with the tinted lenses that were used in the study reported at spatial frequencies of 1.5, 3 and 6 cpd. Hence, this could be the reason for an enhancement in the contrast sensitivity with the 15% tinted lens used in our study at 6cpd. Based on our study and the study reported, there is a difference in the mean contrast sensitivity values between distance and near contrast sensitivity. The possible reasons for the difference between the distance and near contrast sensitivity could be due to the distance of the test, lighting of the room and the design features of the testing charts affecting the viewing. A study reported by De Fez et al., (2002), showed that one of the grey filters which was used as the reference filter in the study with a transmittance percentage of 55% at a wavelength of 380nm, had greater contrast sensitivity compared to the habitual state whereas the other grey filters with transmittance percentage of 25% and 15% had a reduction in contrast sensitivity compared to the habitual state, indicating that the higher the transmittance percentage, the better is the contrast sensitivity [3]. Improvement in contrast sensitivity has been due to the reduction of glare. The use of filters by subjects without any ocular pathology had reported an enhancement in the contrast due to diminished chromatic aberrations, an increase in visibility of the object to be viewed, a decrease in the light scattering or a decline in the lenticular fluorescence. Tinted filters remarkably decrease the luminance of a target which in turn produces an increase in the visibility of the target and therefore, some individuals reported an enhancement in the visual performance. Tinted lenses are known to decrease the illumination and consequently, the luminance is found to be reduced [10]. According to Cox, et al., and Karatepe, et al., it was concluded that there was an increase in contrast sensitivity when the surround luminance was lesser than the mean target luminance [6, 11]. This is because as the surround luminance is reduced which is about 20% of the mean target luminance, there is an improvement in the clarity of the target due to the increase in the ability to discriminate an object from the background with decreasing surround luminance. Hence, this could be another possible reason for an increment in contrast sensitivity with 15% tinted lenses.

From our study, it was also observed that contrast sensitivity was reduced with the 25% grey tinted lens compared to the habitual state. The possible reason could be a decrease in the retinal illuminance in the presence of tinted lens [4]. Moreover, it is well known that the retina responds accordingly to different amount of light whereby, an increment in the retinal illuminance yields in higher enhancement of contrast sensitivity. However, in this case, the retinal illuminance reduces further with the 25% tinted lens due to lesser light transmission compared to 15% tinted lens, therefore, resulting in diminished contrast sensitivity [12]. Based on the research mentioned above by De Fez et al., it could be also noted that the other study filters used such as

blue with a transmittance of 35%, brown and green with transmittance less than 10% when compared to the grey filter with 15% transmittance, the greatest reduction in contrast sensitivity at 6cpd was found [3]. The effect of the tinted lenses on the contrast sensitivity function may occur due to the particular spectral light filtering and alterations in the retinal illumination. In addition, as the lighting reduces, the pupil dilates and there is an increment in higher order aberrations and thus the retina cannot fully detect higher spatial frequencies [13]. When a 25% tinted lens is introduced in front of the eye, the pupil size is thought to be larger compared to without any tinted lenses and with 15% tinted lens. This could be a reason for the reduction in the contrast sensitivity as the pupil size is considered as a factor that influences contrast sensitivity [6]. Pupil dilation causes spherical aberrations, which deteriorates the retinal image quality and yields in a reduction in the contrast sensitivity [14]. According the study reported earlier by Cox, Norman and Norman, it was also concluded that when the mean luminance grating was considerably greater or significantly lesser than the surround luminance, contrast sensitivity was diminished. It was observed that when the surround luminance was remarkably lesser than the mean target luminance which was 3cd/m2 and 7% of the mean target luminance, it showed a decrease in the contrast sensitivity [11]. This is because as the difference in luminance between the surround and the object increases, the contrasts gain decreases and ultimately, there is a reduction in contrast sensitivity.

Besides, our study was conducted under standard fluorescent lighting condition. It is undeniable the fact that, lighting condition is one of the factors influencing contrast sensitivity. Based on a study by Samu et al., it was noted that three different fluorescent lights which were of 3918K, 4141K and 4305K revealed that the contrast sensitivity measured yielded in remarkably small changes among the fluorescent illuminations. Thus, this could eliminate the results pollution for our study [15].

Conclusion

From this study, it can be concluded that different levels of grey tinted lenses have an effect on near contrast sensitivity. Image quality can be easily affected as the contrast sensitivity is influenced by the different gradings such as 15% and 25% grey tinted lenses which affect the contrast sensitivity differently. In this case, the 15% grey tinted lens proved to be better than the habitual state whereas the 25% grey tinted lens was worst compared to the habitual state. Hence, one must consider the spatial aspects of the activities performed before prescribing tinted lenses.

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