Enhancements to Quality of Vision With Photochromic Lenses and Antireflective Coating

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ABSTRACT

Purpose. This study was conducted to determine how patients' quality of vision improved using two popular lens enhancements—photochromic lenses and antireflective (AR) coatings.

Methods. A total of 121 patients, 18 years and older, were randomized into 1 of 4 lens groups. Each group wore a specific pair of lenses for 30 days and then switched to another pair of lenses for 30 days. The CATA group consisted of clear lenses plus AR coating and Transitions® Lenses plus AR coating. The CCA group consisted of clear lenses and clear lenses plus AR coating. The CTA group consisted of clear lenses and Transitions Lenses plus AR coating and the TTA group consisted of Transitions Lenses and Transitions Lenses plus AR coating. The AR coatings used in the study were 6 commercially available products. The Transitions Vision-Related Quality of Life (VRQOL®) instrument (a previously validated questionnaire) measured each patient's visual experience before another lens pair was received for the second 30-day period. After the second 30-day period, a second VRQOL questionnaire was completed. Differences in responses to each lens treatment were calculated.

Results. Over all other lens enhancement options, patients preferred Transitions Lenses with AR. This study confirms that 74% of the patients chose Transition Lenses over clear lenses for VRQOL and 69% of the patients chose AR-coated lenses over non–AR-coated lenses.

Conclusions. Patients expressed overall satisfaction with Transitions Lenses' ability to adapt to different lighting conditions and provide convenience; the addition of AR coating to these lenses was yet a further enhancement to visual quality.

Key words. vision, glare, acuity, antireflective, contrast, photochromic, Transitions Lenses

Traditionally, good vision is primarily a result of an eye examination and the recommendations from the examination. Recent research reveals issues that contribute to the success of vision prescription. Clearly, optimal vision is based on a combination of visual acuity, visual comfort, and long-term vision protection from the ultraviolet (UV) component of sunlight and from bright glaring light.[1]

Light is essential to vision, and the appropriate quantity of light is an important determinant of both visual acuity and visual comfort. Too much or too little light can result in eyestrain, squinting, or eye fatigue. Change in lighting conditions throughout the day can significantly affect the patient's visual acuity and visual comfort.[1] Glare, in particular, contributes to decreased acuity and comfort.

There are several types of glare: distracting, discomforting, disabling, and blinding.[1] Distracting glare results in a general distraction or disruption of clarity or quality of vision leading to eye fatigue. It typically results from reflections off the eyeglass lens surface or within the lens, from streetlights or car headlights at night.[1] The effects of this type of glare are reduced by the addition of antireflective (AR) coating. Discomforting and disabling glare occur when the eye is exposed to too much ambient light. Under normal everyday circumstances, the patient's eye feels a general sense of discomfort, annoyance, and eye fatigue. When exposed to an extreme amount of this type of glare, the perception is of vision impairment; in other words, patients find it difficult to see well or their sight is actually disabled.[1] This type of glare is partially ameliorated by wearing lenses that reduce the intensity of the light, tinted lenses and photochromic lenses, for example. Blinding glare occurs when the patient has difficulty seeing because of extreme conditions caused by intense light reflected off a smooth surface such as water, snow, a window, or a shiny object such as a car bumper.[1] The best way to mitigate the extreme sense of visual impairment is by wearing polarized lenses. In this study, distracting, discomforting, and disabling glare were potentially impacted by the premium lens options used.

The purpose of AR coating is to help eliminate reflections on lens surfaces (distracting glare), thus increasing lens transparency. AR coatings function by reflecting light. The light reflected by the AR coating destructively interferes with the light that is being reflected from the lens substrate or underlying layer (ie, the two lights cancel each other). The

effect minimizes reflections and maximizes transmitted light so that lenses perform as intended.[1] AR coatings must satisfy two fundamental conditions to function properly:

- *The film thickness of AR coatings should be one fourth of the light's wavelength, in the range of 100 to 190 nanometers for visible light. The actual thickness of the AR layer takes into account the reflective index (RI).*
- *The RI of the AR film should be equal to the square root of the underlying lens substrate or the underlying AR film*

To evaluate patient perception and visual quality, a study was conducted to determine if the enhancement of photochromic lenses and AR coatings (individually and combined) would provide additional visual comfort and clinically meaningful improvements in vision-related quality of life.

Methods

Patient Population

The study population consisted of 121 patients who were 18 years and older and evenly split between men and women. Approximately 35% of the participants were between 18 and 25 years of age. Patients were randomized to 1 of 4 lens groups. Sample sizes for the 4 main treatment groups were based on previous studies and chosen so that a difference of 0.75 U could be detected with an acceptable level of confidence. The groups were coded as shown in Table 1.

Current Lenses

The patients provided information about their current lenses at the beginning of the study. The majority wore single vision lenses, were nearsighted, and had had their current lenses for 1 to 2 years. Whether they answered the question or not, 77% did not know their current brand of lenses. The two brand names that were listed included Varilux® and Transitions®. Approximately 48% listed the material of their lenses as plastic, 24% did not know, 20% listed glass, and 11% listed polycarbonate, although some of the subjects may have just been guessing.

Table 1. Treatment Group Definitions.

Code*	Treatment A	Treatment B	Treatment C
CATA	Clear lenses with AR	Photochromic lenses with AR coating	32
CCA	Clear lenses	Clear lenses with AR coating	29
CTA	Clear lenses	Photochromic lenses with AR coating	30
TTA	Photochromic lenses	Photochromic lenses with AR coating	30
			TOTAL 121

CATA=group consisted of clear lenses plus AR coating and Transitions® Lenses plus AR coating, CCA=group consisted of clear lenses and clear lenses plus AR coating, CTA=group consisted of clear lenses and Transitions Lenses plus AR coating, TTA=group consisted of Transitions Lenses and Transitions Lenses plus AR coating.
**Acronym used as the code for the treatment group.*

Special Coatings

Patients were also asked to provide information about scratch-resistant and AR coatings on their current lenses. Knowledge of scratch-resistant coatings was high; 89% of patients indicated they could answer the question, with 63% reported having a scratch-resistant coating. In patients over 55 years of age, 79% reported having a scratch-resistant coating. There were only 13 nonresponders to this question. Similarly, 81% of patients could answer the question about AR coating, of which 34% reported having AR coatings on their lenses. Patients under 25 and patients over 55 years reported having AR coatings more often than those between 25 and 55 years of age. There were 23 nonresponders to this question.

Inclusion in the study

- *Age 18 to 65 years old*
- *Ametropia sufficient to require the use of spectacles for distance vision correction on a routine basis with spectacles worn at least 50% of waking hours*
- *Best corrected spectacle acuity of 20/30 or better in each eye*
- *Refractive correction up to and including +/-4.00 sphere, +/-2.00 cylinder*
- *Availability for follow-up in a timely fashion in keeping with the schedule of the study*

Additional Glasses

Patients were also asked whether they had an additional pair of glasses and whether they were prescription, nonprescription, and/or sunglasses. Of those who a n s w e red the question, 55% reported having at least one additional pair of glasses; the percentage increased proportionately with age. Of those with secondary glasses, 59% reported using sunglasses (prescription, nonprescription, or clip-on).

Study Procedure

During two separate periods, study participants were given one pair of treatment lenses to wear for a 30-day period and then asked to complete a Transitions Vision-Related Quality of Life (VRQOL©) questionnaire. Patients were then allowed to select one of the two lens pairs to keep for their use. Frames remained the same for both cells.

Products Included in Study (Table 2)

Table 2. Products Included in Study.

Lens Product	Indoor Transmission	Outdoor Transmission
Transitions Lenses with AR* coating	95%	15%
Transitions Lenses	89%	15%
CR-39 with AR* coating	97%	97%
CR-39	92%	92%

**A pool of six commercially available AR coatings.*

Study Analysis

The two primary subsets considered were the difference between the photochromic lenses and clear lenses (CTA and CATA treatment groups) and the difference between the AR-coated and noncoated lenses (CCA and TTA treatment groups). The primary objective was to determine if patients perceived a difference between the two sets of lenses and to be able to characterize the difference.

For every item on the VRQOL questionnaire, each patient's answer was calculated using the difference between the ratings given for each type of lens enhancement worn. If the calculated difference was zero, this meant that there was no perceived difference in the two lens treatment types. To minimize the effects of lens order on the patient's perception, a randomization scheme directed some study subjects to wear one type of lens first and then switch to the other type. The order in which the lenses were worn did not have a statistically significant effect on any of the question outcomes. Questions were deemed significant if the *P* value associated with the hypothesis test for equivalence was ≤ 0.05, meaning that there was, at most, a 5% chance of declaring a difference significant when it was not.

Results

Age Distribution

Study participants were at least 18 years of age with the majority of participants being between 18 and 25 years of age. The 36- to 45-year-old group was the least represented group of the 5 age groupings considered. The balance of age groups within each treatment group (given the overall proportion of each age group) was acceptable, although there were some groups that were represented by a greater number of participants than others. For example, a larger proportion of study subjects over the age of 55 were assigned to the CATA treatment group and a larger proportion of subjects from the 26- to 35-year-old group were assigned to the TTA treatment group. Neither was believed to have had any influence on the outcome.

Gender

The overall distribution of men and women in the study was about even. For the 2 treatment groups, CCA and TTA, the balance between men and women was equal. In the CATA treatment group, there were 7 more men than women and in the CTA treatment group there were 4 more women than men.

Preferences

The survey was divided into 5 parts to evaluate the patients' responses when wearing the lenses for visual comfort, during daily activities, conditions experienced, features, and satisfaction. Details of the survey findings for the comparison of clear vs photochromic lenses and AR vs non-AR subsets are summarized in Tables 3 and 4.

Table 3 outlines the specific activities that showed to be statistically significant in the comparison of photochromic lenses vs clear lenses. Overall, 74% of patients preferred Transitions Lenses over clear lenses. Table 4 outlines the specific activities that showed to be statistically significant in the comparison of AR vs non-AR lenses. Overall, 69% of patients preferred AR products over non-AR products.

Final Lens Choice

At the conclusion of the study, each patient was requested to select 1 pair of lenses to retain as their primary pair. Overall, Transitions Lenses with AR coating were preferred over all other premium lens options by roughly three quarters of the patients (cells 1, 3, and 4, see Figure).

When there was a choice between clear lenses and Transitions Lenses, 74% (46/62) chose Transitions Lenses (cells 1 and 3, see Figure).

When comparing the same product with and without AR, 69% of patients chose AR products (cells 2 and 4, see Figure).

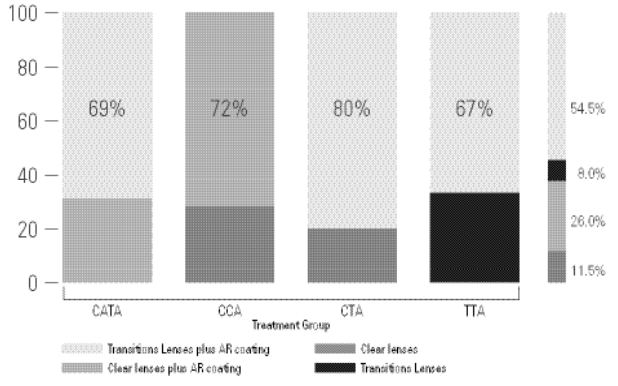

Table 3. Summary of Statistically Significant Findings in the Photochromic vs Clear Lens Cells (CATA and CTA)

Survey Section	Results
Visual Comfort (6 questions)	Photochromic lenses were preferred: • In bright light • For seeing at night in the presence of bright light sources • When reflective glare was encountered • When adjusting from indoor to outdoor light • When adjusting from a dimly lit room to bright sunlight
Daily Activities (14 questions)	Photochromic lenses were preferred: • In the presence of reflections from lenses (day and night) • For watching TV or movies • For completing paperwork • For reading at the end of the day • For performing outdoor activities • For driving (day or night) Photochromic lenses and clear lenses were equivalent when: • Reading fine print under dimly lit conditions • Reading computer screens • Performing indoor activities
Conditions Experienced (3 questions)	Photochromic lenses were preferred with regard to: • Reduced pain • Minimal loss of visual function as a result of glare Photochromic lenses and clear lenses were equivalent with regard to: • Frequency of eyestrain • Tearing in bright sunlight
Features (7 questions)	Photochromic lenses had better UV protection than clear lenses. Photochromic lenses and clear lenses were equivalent with regard to how others viewed the appearance of their lenses Photochromic lenses were good or very good with regard to: • The ability to adapt to different lighting conditions • The speed at which the lenses adjusted from indoor to outdoor conditions • The ability of the lenses to darken and stay a uniform color
Satisfaction (8 questions)	Patients were satisfied with the ability of photochromic lenses to adapt to different lighting conditions. Photochromic lenses and clear lenses had no perceived differences with respect to: • The appearance of the lenses • Ease of adjustment to the lenses • Overall satisfaction

Table 4. Summary of Statistically Significant Findings in the AR vs Non-AR Cells (CCA and TTA)

Survey Section	Summary Results
Visual Comfort (6 questions)	AR-coated lenses were preferred: • *When reflective glare was encountered* • *When adjusting from a dimly lit room to bright sunlight* AR-coated and noncoated lenses were equivalent for: • *Seeing at night in the presence of bright light sources* • *Adjusting from outdoor to indoor conditions*
Daily Activities (14 questions)	AR-coated lenses were preferred in the presence of reflections from lenses (ie, distracting glare) during the day AR-coated and noncoated lenses were equivalent for: • *Watching TV or movies* • *Completing paperwork* • *Reading at the end of the day* • *Performing outdoor activities* • *Driving either in the daytime or at night* • *Reading fine print under dimly lit conditions* • *Reading computer screens* • *Performing indoor activities* Patients found noncoated lenses easier to keep clean; however, they were not given specific cleaning instructions for the AR lenses.
Conditions Experienced (3 questions)	Patients wearing AR-coated lenses reported lower frequencies of: • *Pain or loss of visual performance due to glare*
Features (7 questions)	AR-coated and noncoated lenses were equivalent in: • *How others viewed the appearance of their lenses* • *The UV protection provided by the lenses* • *Overall photochromic performance (changeability characteristics) where applicable*

Discussion

This study involved a group of 121 patients of different ages and was equally balanced between men and women. After wearing each of two different types of lenses, participants were asked to fill out a survey that characterized their reaction to that specific pair of lenses. Participants were not asked to compare one pair of lenses to another pair or to rank them in any relative way. Patients wore their lens treatments during normal day-to-day, daylight-to-nighttime activities. Approximately three fourths of the patients indicated that Transitions Lenses were preferable with regard to overall visual comfort and their ability to adapt to different lighting conditions.

The normal cornea, lens, and vitreous scatter 10% to 20% of incident light. Glare is caused by light scatter and is influenced by the dynamics of light-to-dark-to-light adaptation and by retinal photoreceptor saturation. In the normal eye, increasing levels of glare will increase baseline incident light scatter and adversely affect contrast sensitivity. The result is visual discomfort and fatigue.[1]

As previously mentioned, optimal vision is based on a combination of acuity, comfort, and protection. The premium lens options included in this study provided enhancements to a combination of all of these. Patients experienced good visual acuity in all products (clear, photochromic, AR, and non-AR) as measured by the Transitions VRQOL instrument. Vision protection was achieved by the photochromic lenses' automatic blocking of 100% of UV radiation. Visual comfort, by reducing discomforting and disabling glare, was enhanced with photochromic lenses. The study showed that visual comfort was also enhanced by reducing distracting glare with the addition of an AR coating. It can be surmised that visual comfort was most enhanced by reducing distracting, discomforting, and disabling glare with the addition of both premium lens options.

This is an important clinical study because it establishes criteria by which lens choices can and should be made in practice. Indeed, the results of this study showed that an overwhelming number of the patients studied preferred AR-coated Transitions Lenses. Although Transitions Lenses are always an excellent choice for patients because of their well-established benefits, the findings in this study provide additional compelling support for the clinical decision to recommend Transitions Lenses with AR coating to all appropriate patients.

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