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Original Article

EFFECTS OF THREE EYE GLASS FRAME DESIGNS ON RELATIVE HUMIDITY AND TEMPERATURE MEASURED OVER THE CORNEA

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ABSTRACT

Objective

To evaluate the relative humidity and temperature over the cornea in three different eye glass frame designs to see if frame design can influence relative humidity and temperature measured over the eyeball surface.

Setting

Ophthalmology practice in the Denver, Colorado area.

Design

Prospective study

Materials and Methods

Relative humidity and temperature were measured in 59 subjects in a clinical setting, with three different eyeglass frame designs from June 2016 to September 2016. Measurements were made with small sensors mounted inside the eye glass lenses, to see if eyeglass frame design could influence these measured values. Baseline measures were taken with glasses off and follow-up measures with glasses on.

Results

Relative humidity increased most markedly with a tight wraparound frame design (38.9%), followed by a smaller increase with post-cataract wraparound sunglass frames (2.8%), and a minimal decrease with normal frames (–1.3%). The temperature increased over the eyeball in all frame designs but changed most dramatically in the tight wraparound frame (11.2 degrees).

Conclusion

Tight wraparound eyeglass frames significantly increase the relative humidity over the cornea, as measured in this study. This frame design may offer another method of treatment for dry eye disease that is lower in cost than present therapies.

The purpose of this study is to evaluate the relative humidity and temperature over the cornea in three different eyeglass frame designs to see if frame design can influence the relative humidity and temperature measured over the corneal surface.

Dry eye disease is a significant ocular problem in the U.S., estimated to affect 20,000,000 people.[1] Studies in the U.S. show that approximately 15% of older people have this problem,[2] and as many as 33% of people suffer from dry eye disease in Asia.[3] Twenty-five percent of patients visiting ophthalmic practices report symptoms of dry eye disease.[5] The incidence of Dry Eye Disease is greater at higher altitudes,[16] which makes this problem more prevalent and significant in places like Colorado. Dry eye disease has a significant impact on the quality of life. Patients with dry eye disease often experience significant ocular discomfort as they try to complete visual tasks.[4]

Almost all treatment strategies for dry eye disease are directed at medical therapies. Treatment often starts with artificial tears,[7] and then may advance to the use of punctal plugs,[8] cyclosporin drops,[9] and autologous serum tears.[10] In recent years more novel therapies such as LipiFlow Vectored Thermal Pulsation Therapy[11] have been developed to try to improve Meibomian gland function. In contrast to these types of therapies, relatively little has been written about how to alter the relative humidity over the corneal surface, although it is well known that increased relative humidity can decrease the severity of dry eye symptoms.[6] If the relative humidity could be increased over the cornea then presumably the symptoms of dry eye disease could be reduced.

Dry eye disease is most often associated with advancing age, female sex, low relative humidity, use of certain medications, and cigarette smoking.[6] Environmental issues greatly affect relative humidity, including the relative humidity of certain areas of the world, and the relative humidity of internal environments such as office buildings, homes, and automobiles. The internal relative humidity of many office buildings and vehicles is often kept at extremely low levels.[6] Certain designs of eyeglass frames can increase the relative humidity over the cornea by trapping the moisture naturally produced by the skin and cornea. This trapped moisture would have the potential of decreasing the severity of dry eye symptoms by decreasing evaporation of the aqueous layer.[12] Although certain eyeglass frames can alter relative humidity, this treatment method is not commonly used in the treatment of dry eye disease.

One of the possible reasons that there is a lack of enthusiasm for this therapy, is that it is hard to know how effective a given frame design might be in increasing the relative humidity over the cornea. This study utilizes a novel approach for the measurement of the relative humidity and temperature over the cornea, by utilizing small sensors installed inside the eyeglass lenses of three different eyeglass frame designs. The present study measures the relative humidity and temperature at baseline with the glasses off, and again after the participant has worn the glasses for five minutes. This allows for an accurate assessment of how eyeglass frame design affects the relative humidity, and so may be a good indicator of the potential of a frame design to treat dry eye disease.

MATERIALS AND METHODS.

This study received approval from the Colorado Multiple Institutional Review Board and informed consent was obtained from all participants. The setting for the study was a private ophthalmology practice located in Denver, Colorado.

DESCRIPTION OF THE SENSORS

The study utilized small sensors measuring 19 × 19 × 2 mm, produced by Sensirion Corporation (item number SHT15). The sensors are designed to measure both temperature and relative humidity and have a published accuracy of measurement of +/− 2% relative humidity. The sensors are small in size which allows them to be attached to the lenses of eyeglasses, and the eyeglasses can still be worn without difficulty. In our study, a sensor was bolted to the inside of one of the lenses. The sensor was used to evaluate changes in the relative humidity and temperature over the cornea. The sensors were connected to a computer and the readings were recorded electronically.

Description of the Eyeglass Frame Designs

There were three types of eyeglass frames used in this study (see photo 1). The first frame design was a typical eyeglass frame with the lenses positioned about 10-15 mm. in front of the corneas, with no significant skin contact around the front of the eyes. The second frame was a pair of wraparound sunglasses, typically issued after cataract surgery, with minimal contact with the skin of the face. The third frame was a pair of tight wraparound sunglasses with significant contact with the skin around the eyes. In most of the study participants the eyeglasses were in contact the skin along the brow, the nasal area, and the inferior aspect of the cheek, but there was no contact with the skin on the temporal aspect of the face. This contact with the skin of the face allows for trapping of the air in front of the cornea, and this is why the humidity increases so significantly.

Measurement of Relative Humidity and Temperature

The test glasses were taken off of the patient and allowed to equilibrate to the ambient relative humidity and temperature of the testing room. All measurements were obtained indoors in an office setting.

Photo 1 Eyeglass frame designs.

The glasses were then put on the face of the subject, and 10 measurements were taken over a period of 5 minutes from the inside sensor. The last of the ten measurements was used since the relative humidity and temperature were stable by this time. These measures were compared to the baseline measurements.

STATISTICS

Paired t-tests were used to determine if there were any differences between mean relative humidity and mean temperature when glasses were on and the glasses off within the specific glasses type, while ANOVAs were used to determine if the change in relative humidity and temperature when glasses were on/off differed between the three types of glasses frames. P-values less than 0.05 were deemed statistically significant. Statistical analyses were performed in SAS 9.4 (SAS Institute Inc, Car, NC).

RESULTS

Nineteen or twenty subjects were tested with each of the three frame types, although very few of the test subjects were tested with all three frame types. We show in Table 1 the difference in the mean relative humidity and temperature in subjects wearing regular glasses, cataract glasses, and wraparound glasses. The normal eyeglass frames showed a minimal change in relative humidity. The mean relative humidity was 50.4% ± 5.0 with glasses off and 49.1% ± 4.9 with glasses on, with a P value = 0.0195 (Table 1). The temperature measurement showed a gradual increase over time in all cases.

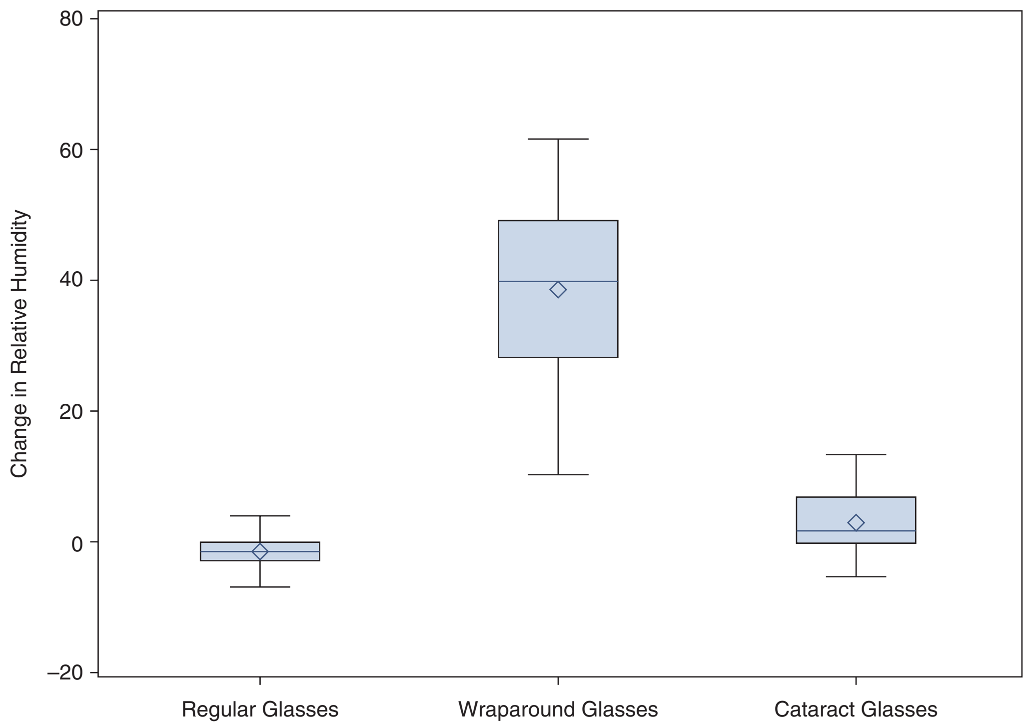
The post-cataract frames showed a relative humidity of 52.3% ± 4.5 with the glasses off, and 55.1% ± 6.3 with glasses on, for an increase of 2.8%. There was a gradual increase in temperature over time as well.

By far the greatest difference in relative humidity was found with the wraparound frames. With glasses off the relative humidity was 38.4% ± 5.0 increasing to 77.3% ± 11.8 with glasses on. (seeTable 1 and Figure 1) On average the wraparound frames increased the RH by 40%. The temperature increased over time about 11 degrees with the wraparound frames, which was also greater than the temperature increase in the other frame types.

TABLE 1 Differences in Relative Humidity and Temperature in the Regular, Cataract, and Wraparound Glasses Group

Regular glasses (n=19)	**Glasses off**	**Glasses on**	**P-Value**
Mean Relative Humidity	50.4 ± 5.8	49.1 ± 4.9	0.0195
Mean Temperature	72.5 ± 2.3	76.2 ± 1.5	<0.0001
Cataract Glasses (n=20)			
Mean Relative Humidity	52.3 ± 4.5	55.1 ± 6.3	0.0272
Mean Temperature	70.0 ± 1.2	74.9 ± 1.4	<0.0001
Wraparound Glasses (n=20)			
Mean Relative Humidity	38.4 ± 5.3	77.3 ± 11.8	<0.0001
Mean Temperature	71.4 ± 1.0	82.6 ± 3.7	<0.0001

FIG. 1 Differences in the change of relative humidity when glasses are on and off by type of glasses.



The baseline humidity was lower in the testing room when the wraparound frames were tested compared the other frame types. This is because the regular frames and the cataract frames were tested in the summer and the wraparound frames were tested in the fall. In spite of this difference in baseline measurements, the increase in relative humidity was so great with the wraparound frames compared to the other frames, that the difference would still be strongly statistically significant.

DISCUSSION

This study found that the relative humidity over the cornea increases significantly when tightly fitting wraparound glasses are used (+40%). Although the relative humidity changed slightly with the regular frames (−1.3%) and cataract frames (+2.8%), this difference was so slight that one could conclude that only the wraparound frames produced a change that could be clinically meaningful.

As more is understood about dry eye disease, the therapies for this problem are becoming more complex.[6] Unfortunately, in many patients, no one treatment is completely successful. It is therefore, rather common these days to treat a patient with several modalities at the same time.[13] A thorough evaluation of each case is required, to know the true nature of the problem. A patient might have Meibomian gland dysfunction, or low aqueous production, or both. They might have an underlying problem such as blepharitis, or inflammatory disease, and all these issues would need to be addressed to treat their problem in the most effective way possible.

A common problem in dry eye disease is that the tear film breaks up too quickly, and the aqueous layer evaporates too rapidly. The corneal surface then becomes vulnerable to damage from the environment.[6] Presumably, any treatment that delays or halts the evaporation of the aqueous layer could improve the symptoms of dry eye disease. Madden et al, described the effects of various levels of relative humidity on the tear evaporation rate in a series of patients with and without dry eye disease.[14] They utilized a special room with relative humidity control, and measured tear evaporation rates for these patients, at 5%, 40%, and 70% RH. It was found that tear evaporation rate in dry eye patients was extremely rapid at 5% RH. When the RH was increased to 40%, the tear evaporation rate was significantly extended in dry eye patients, and at 70% RH the tear evaporation rate became negligible in dry eye patients.

Results from Maddens et al's study suggest that if the relative humidity over the cornea could be increased to 70%, that patients with DED might enjoy a significant benefit, because the tear evaporation rate would decrease to zero. The present study shows that a relative humidity of 70-80% is easy to reach with tight wraparound eye glass frames, but not with normal frames or cataract frames. The tight wraparound frames appear to trap humidity over the corneal surface because of skin contact in the area of the brow, cheek, and nasal region of the face.

Several websites sell "dry eye glasses," which vary in design, but little is known about the effectiveness of these glasses in elevating the relative humidity over the corneal surface. This study utilizes a novel approach to the measurement of relative humidity and temperature over the surface of the cornea while wearing eyeglasses. This method could be used to evaluate the ability of any "dry eye" frame to increase the relative humidity over the corneal surface.

The design of "dry eye" frames is critical if one wants to increase the humidity over the cornea. The frame must come in contact with the skin surrounding the eye in a sufficient manner that a pocket of air is trapped over the corneal surface. The eyeball and the skin in the area can then produce enough water vapor that a "moisture zone" is created. If there is too much of a gap between the frame and the facial skin then the relative humidity cannot be increased at all, as demonstrated with the use of normal frames in this study. In the course of performing this study, it was noted that several patients did not have a perfect fit with the wraparound eyeglass frames. This is likely the reason that the standard deviation was rather high for this frame design. Since every person has a different shape to the facial bones, it is crucial that a wraparound frame is selected to fit a particular facial contour.

In this study we have shown how the use of a small sensor mounted to the inside of the eyeglass lens can produce accurate data to demonstrate how much a particular eyeglass frame design increases the relative humidity over the cornea. This information could be helpful in selecting a group of patients to evaluate the impact of these types of glasses on the course of dry eye disease.

CONCLUSION

The present treatment of dry eye disease utilizes many different types of therapies that are only partially effective. Utilizing custom eyeglass frames that significantly increase the relative humidity over the cornea could provide a significant addition to the way we treat this extremely common and bothersome problem.

FINANCIAL DISCLOSURE

No author has a financial or proprietary interest in any material or method mentioned.

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