Abstract

Aim: Assessment and comparison of the thermal changes of ocular surface in patients with and without contact lens (CL) use. Materials and methods: In this cross-sectional observational study, infra-red imaging of ocular surface was done for sixty eyes of 30 contact lens users and 60 eyes of 30 age-matched normal healthy individuals. Results: Temperature deviations (dT) in right eye of CL non-users and CL users was -0.167±0.199 and -0.494±0.406 respectively (p = 0.0002). In left eye, the dT was 0.161±0.183 and 0.433±0.308 in the CL non-users and in CL users respectively (p = 0.0011). Intra-group comparison of CL users with and without their lenses did not reveal any difference (p = 0.57 for right eye, p = 0.37 for left eye). The duration of use showed no linear relationship with the mean dT of individuals. Conclusion: Significant difference in the thermal temperature of the ocular surface occurs in eyes with a prolonged contact lens use than eyes without contact lens.

Keywords: Oculothermography, Contact lens, Ocular surface disorder.

Prolonged contact lens usage leads to lower tear meniscus volume with significant dry eye and visual symptoms triggered by environmental factors. Dynamic changes in the tear menisci, non-invasive tear break-up time (NITBUT), and comfort level were evident in both inexperienced and experienced Contact Lens wearers. Biochemical changes brought about by the influence of the contact lens on the tear film are conveniently split into two categories. Firstly, the lens can remove or reduce the levels of specific components in the tear film, and secondly, the lens can augment the tear film, by stimulating the influx of new components or increasing the level of existing components. The interactions are affected by the properties of the lens, the characteristics of the individual wearer and the wear schedule.

Dry eye refers to a group of conditions characterised by irritated, gritty, burning eyes and clinically by alteration in tear film and anterior surface of the eye. At the National Eye Institute workshop, dry eye was classified as “a disorder of the tear film due to tear deficiency or excess tear evaporation resulting in interpalpebral ocular surface damage and is associated with symptoms of ocular discomfort”. Dry eye occurs due to inadequate tear production and/or excessive tear evaporation resulting in unstable tear film and symptoms of ocular discomfort and prolonged contact lens use is a major risk factor for the development of dry eyes. It is a common condition also seen with increased prevalence in patients with autoimmune disease, postmenopausal women and the elderly. Dry eye due to contact lens use is a tear film dysfunction and it leads to ocular surface inflammation. All these situations like aqueous deficiency, excess evaporation and inflammation are supposed to change the ocular surface temperature (OST).

Infrared thermography is the science of acquisition and analysis of thermal radiation from a surface, by using non-contact thermal imaging devices. Here the device senses the infrared radiation (750nm-1mm) from a defined area of interest and produces an image with colour code: hottest area as red and coolest area as blue. A typical infrared detection system has the following configuration- Infrared source > Transmission system > Optical system > Detector > Signal processing > Image formation. Thermography is commonly used in Rheumatology, breast cancer detection, dermatology. Its use in eye disorder is also more than 50 years old. Mapstone et al measured the ocular surface temperature in 1965 using a bolometer. Among the eye diseases retinal vascular obstruction, ocular inflammatory conditions, ocular tumours, and dry eye syndrome are of special interest. All these conditions affect the total amount of infrared radiation. It is widely acknowledged that the ability to measure ocular temperature accurately will increase the understanding of ocular physiology. In thermometry of the human eye, contact techniques have...
largely been superseded by infrared imaging, providing a non-invasive and potentially more accurate method of temperature measurement. Ocular thermography requires high resolution and frame rate: features found in the latest generation of cameras. Applications have included dry eye, contact lens wear, corneal sensitivity, and refractive surgery. Dynamic changes in the tear menisci, NITBUT, and comfort level were evident in both inexperienced and experienced Contact Lens wearers. Temperature always tends to decrease on a vital mucous membrane surface such as an ocular surface always wetted with moisture such as tears, etc., due to the heat of vaporization, where the temperature decrease due to the heat of vaporization is more considerable with increasing water wettability and thus the vital tear wettability of eyes in other words, the vital tear dryness, can be determined by analysing changes in the ocular surface temperature. It has been further found that the ocular surface temperature starts to decrease just from one blinking due to the heat of vaporization in the tear evaporation from the ocular surface, and the quantity of evaporated tears increase so long as there is a sufficient quantity of tears on the ocular surface, resulting in abrupt decrease in the ocular surface temperature and in case of dry eyes, on the other hand, the quantity of evaporated tear decreases, resulting in gentle decrease in the ocular surface temperature. As a result of further extensive studies on the basis of these findings, it has conceived that the tear wettability of ocular surface determined by analysing changes in ocular surface temperature after one blinking can serve as a significant indicator for diagnosing dry eyes, the present invention is based on this new conception.

Oculothermography may provide a non-invasive method of determining these thermal changes and hence, may prove to be a useful tool in the future to screen patients with risk factors for dry eyes.

Materials and methods:

The study subjects were included from those who attended the contact lens clinic of a medical college, Kolkata India with informed consent and permission from the Institutional ethics committee. Those with continuous contact lens use for more than 6 months and normal Schirmer’s test result, normal TBUT result, and without any abnormal fluorescein staining of ocular surface were included. The controls, contact lens non-users were selected from the students and staff of the Hospital. The present study was conducted with sixty eyes of 30 contact lens users as cases (group1) and 60 eyes of 30 age matched normal healthy individuals as control (group2). History of any autoimmune disorder, any chronic drug intake, allergy to any proteins like egg, fish etc was exclusion criteria. It was made sure that the patient did not use any eye drops on the day of clinical examination or washed face with cold or hot water prior to imaging and restrained from any strenuous physical exercise. Thermal image was taken with thermal imaging camera (FLIR SC300) (Figure 1). The first image was taken with normal blinking. Then the patient was instructed to wide open the eyes for at least 10 seconds and images taken. The chief parameter for comparison was thermal score, mean temperature deviation (dT) in the central cornea, measured with thermal cameras. During analysis for standardization the mean dT of central 10 pixel by 10 pixel area of ocular surface was used. Mean of the series of mean dT for each individual was calculated and compared. Contact lens users were compared with non-users and they were also compared among themselves with their contact lenses on and off. In the study the analysis of the data has been done using MATLAB software.

Results:

Mean age of patients was 25.7±2 and 88.27.3±4.8 years in group 1 and group 2 respectively. Group1 had 5 males and 25 females. Group 2 consisted of 10 males and 20 females. All in both the groups used soft contact lenses and had indoor work environments. In the groups, no linear relation was found between the duration of lens use and mean temperature deviation (dT).

Temperature deviations (dT) in right eye of group 2 and group 1 was -0.167±0.199 and -0.494±0.406 respectively (P = 0.0002) (Figure 2). In left eye, the dT was -0.161±0.183 and -0.433±0.308 in the CL non users and in CL users respectively (P = 0.00011) (Figure 3). Both the scatter diagrams show that mean dT of group 1 with contact lenses...
are much more diffusely situated than group 2. Mean dT of right eyes in group 1 without their contact lenses on was -0.30184±0.73313 for both right eye and left eye (Figures 4 & 5). Intra group comparison in group 1 with and without their lenses, difference was not significant with a p value of 0.57 and 0.37 for right and left eyes respectively. (Figures 6 and 7).

The right eyes of group 1 showed a Schirmer’s reading of 15.93±1.57 mm and group 2 of 16.47±1.38 mm (p= 0.62). The left eyes of group 1 showed a Schirmer reading of 15.8±1.42 mm and group 2 of 16.17±1.55 mm (p= 0.34). The right eyes of CL users showed a TBUT score of...
12±1.17 seconds and non-users of 12.06±1.44 seconds (p= 0.84). The left eyes of CL users showed a TBUT score of 12±1.14 seconds and non-users of 12.2±1.24 seconds (p= 0.52). Hence, Schirmer’s and TBUT showed no significant difference between the two groups.

**Discussion:**

The major outcome of this study is that there is a significant difference in the thermal temperature of eyes with a prolonged contact lens use than eyes without any use. And this temperature difference can be detected using thermal imaging and a well-defined algorithm. Also, the difference noted is more in the state where individuals have their lenses on as compared to the situation when they are off their lenses. This could mean that the thermal temperature regulation is not working in the proper manner when contact lenses are in use. Even when contact lenses are taken off, there is somewhat a temperature dysregulation. The duration of use showed no linear relationship with the mean dT of individuals. There was no significant difference in Schirmer’s test and TBUT results between the two groups.

There are various studies showing the difference between the oculothermographic picture of dry eye patients and normal individual as well as in individuals with prolonged contact lens use. Most of these studies showed the temperature deviation (dT) after blinking is higher in dry eye patients. Scott et al in their study documented that the higher evaporation related loss of latent heat outweighs the inflammation related increase in temperature and probably this may the cause of high dT in dry eye patients. Purslow C et al found that ocular surface temperature is greater with hydrogel and greater still with silicone hydrogel contact lenses in situ, regardless of modality of wear.

It is concluded that, the results can prove to be a stepping stone for future research to develop a compact algorithm for a quick, non-invasive method which would be able to detect thermal dysregulation early, correlate with symptom scores and prevent development of dry eye related complications in contact lens users. Oculothermography or thermal studies may prove to be the future non-invasive diagnostic tools to detect development of dry eyes in the pre-clinical stages in individuals using contact lenses. These results can be extrapolated to other ocular conditions as well and further research could be carried out to define proper guidelines in order to make full utilisation of this tool in clinical setting.

However, the present study could not elucidate a reason for this difference in thermal imaging and probably there is an unknown underlying mechanism which needs to be uncovered for better understanding of the outcomes. The sample size is too small to be relied upon and this study can be treated as a pilot study for future research in this area. This study enrolled patients using soft contact lenses only. There was no monitoring of the manufacturing companies. There is a good possibility in difference existing between lenses of two different manufacturers.

**References:**