Int. J. Chem. Sci. : 2 (2), 2004, 135–140

THE EFFECT OF CONTACT LENS WEAR ON THE PRECORNEAL TEAR FILM pH

ALI ERFANI KARIMZADEH TOUSI* and REYHANEH SARIRI**

* Valieasr Hospital and Medical Center, RASHT, IRAN,
**Department of Biology, Gilan University, RASHT, IRAN

ABSTRACT

Contact lenses have become an essential part of many people's lives. Despite many advantages, the widespread use of contact lenses has brought about attention to their associated problems. Although many investigators have studied the effect of tear environment on lens spoilage, the change in tears biochemistry such as protein pattern, pH and buffering capacity have received less attention. The main purpose of this study was to compare the pH value in precorneal tear film of contact lens wearers with normal, non–contact leas wearers.

The pH values were measured using a micro–pH electrode in two subject groups: a group of contact lens wearers and a second group of normal non–contact lens wearer volunteers with similar age, sex and health conditions. The mean pH value measured for the un–stimulated morning tears (before wearing contact lenses) was 7.6. Stimulation of tear secretion and increased blinking due to the use of contact lens led to a decrease in the pH value compared to normal volunteers. The pre–corneal tear film is alkalized by equilibration with partial pressure of the CO_2 in the surrounding air. In the case of contact lens wearers, CO_2 retention and hypoxia acidosis together with possibility of increased blinking leads to lower tear pH values.

Key words: Pre–corneal tear film, Contact lenses, Tear pH, Tear buffering capacity

INTRODUCTION

Contact lenses have been used to correct errors of refraction, as protective devices for the eyes against undesirable fluids, gases or solids; as a mechanical aid in the treatment of several pathological eye conditions; for their cosmetic effect in neurologic conditions associated with eye defects; as a valuable aid to vision where the wearing of spectacles is impossible such as swimming; as a vocational aid to vision; as a cosmetic device to change the color of the eye, and as the only refractive device which will give useful vision in certain abnormal conditions. The rapid increase in contact lens wear has led to a greater incidence and renewed awareness of lens

***Mailing addresses:**
A. Erfani, Emergency Department, Valieasr Hospital, Polearagh, Rasht, Iran
Tel: +98 131 5555286 Fax: +98 131 3220912, E–mail: alierfani2002@yahoo.com
R. Sariri, Department of Biology, Gilan University, Namjoo Street, Rasht, Iran
Tel: +98 131 3224006 Fax: +98 131 3220912, E–mail: sariri@guilan.ac.ir

related problems. One of the problems, usually associated with contact lens wear is the adsorption of tear proteins onto them. The identity and quantity of various tear protein adsorbed onto contact lenses, factors determining their adsorption and competitive protein adsorption have been studied[1–8]. Another important problem, which has not been studied in great detail, is the possible change of the tear pH due to the use of contact lenses. In human cornea, active Na^+ and Cl^- transport and thus the maintenance of corneal transparency are pH–dependent[9]. Although some buffer systems are present in tears, there may be some changes in tear pH of contact lens wearers due to its stimulation and lactate formation.

To understand corneal physiology, it is important to know the pH value in the three–layered pre–corneal fluid film under normal conditions[10, 11]. Investigations on the normal human tear pH have shown pH values of 5.2–8.6[12, 13]. It has been found that the corneal epithelial and endothelial cells become acidotic during *in vivo* contact lens wear in rabbits[14]. In this study, the effect of contact lens wear on human tears pH was studied using direct pH measurements[15]. The pH value of lacrimal fluid was measured in inferior fornix of the conjunctiva without touching and stimulation. Although direct measurements of the precorneal fluid using glass electrodes have been reported for non contact lens wearers[16], there are no reports in the literature about the value for contact lens wearers. We used the direct pH measurement method to study the lacrimal fluid of contact lens wearers as well as normal subjects and discussed the effect of wearing contact lenses on the tear pH.

METHODS AND MATERIALS

Materials and solutions

Focus™ tinted Group IV soft contact lenses, Vifilcon A polymer, EWC 55% from Ciba vision. All–in–One ReNu™ multi purpose care solution. Metrohm's sensitive micro–pH electrode, pH meter, KH_2PO_4 / Na_2HPO_4 buffer solutions with pH value of 6.2 and 7.6, TRIS (hydroxymethyl aminomethane) buffer.

Methods

45 volunteers, 20 contact lens wearers (LW) and 25 controls (CTR) entered the study. In order to minimize all possible interfering variables, the subjects were all female in the age group of 20–25. Also the history of using contact lenses among the wearer group was similar in the range of 22–24 months. Informed consent was obtained from all participants and their eye conditions history in terms of various eye diseases recorded. All volunteers were asked for subjective symptoms such as itching, burning, photophobia and possibility of present or previous eye disease. The subjects who suffered from any of those symptoms or had a history of eye infection were left out of the study. The precorneal lachimal fluid pH was measured using a Metrohm's sensitive micro–pH electrode (tip diameter 3 mm). All of the LW subjects were provided with Focus™ tinted Group IV soft contact lenses, Vifilcon A polymer, EWC 55% and

were told to use All–in–One ReNu™ care solution according to its manufacturer recommended procedure. No enzyme tablets or rewetting drops were used during the study. Both groups were told to refer to the laboratory for tear pH measurements every day at 10.0 am. The contact lens wearers were told not to wear their lenses before they come to the laboratory and a first pH measurement was made. They then inserted their lenses and their tear pH value was recorded again. In order to study the effect of bliking and avoid bliknking at different time intervals, the participants were allowed to blink deliberately each 30 seconds while measuring their tear pH values.

They all were told to keep their lids closed for 15 seconds and the pH values were recorded beginning 40 seconds after opening of the lids. Recordings were then made every 5 seconds for a time interval up to 45 seconds. Unilateral (left eye) pH measurements of pre–corneal tear fluid were measured in inferior fornix of the conjunctiva without touching the same. The electrodes were placed on the measuring point 40 seconds after the eyelids were opened.

Three buffer solutions were used to calibrate the measuring chain. Solution 1 was adjusted with KH_2PO_4 / Na_2HPO_4 to a pH value of 6.2; solution 2 was adjusted with the same buffer solution to a pH value of 7.6; solution 3 contained TRIS (hydroxymethyl aminomethane) buffer and was brought to pH 10.0. The reference electrode was filled with solution 2.

RESULTS AND DISCUSSION

Figure 1 shows recording of continuously measured pre–corneal tear pH among lens wearers and normal subjects. The equilibration with partial pressure of CO_2 of the surrounding air can be observed in this figure. A relatively stable pH in alkaline range is reached approximately 85 seconds after opening of the lids. The decrease of tear pH is due to blinking. Table 1 represents variation in tear pH with time after opening the lids among normal and lens wearers.

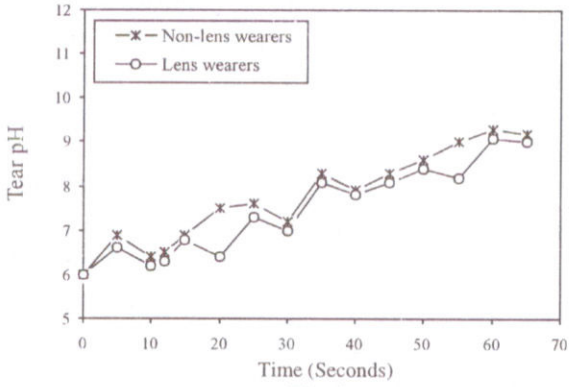

Fig. 1

According to our measurements, the mean pH value measured for the unstimulated tears before wearing contact lens was 7.6. Stimulation of tear secretion and blinking led to a decrease in the pH value, wearing contact lenses also caused a decrease in the mean pH value. The value returned to normal after about one hour of lens removal. The variation in the tear pH can be explained as follows. When eyelid is open, the pre–corneal tear film can be alkalized by equilibrium with partial pressure of the CO_2 in the surrounding air. When the eyelid remains open for 60 s or longer, equilibrium values of pH > 9 are attained. In the case of contact lens wearers, three separate and additive effects cause the decrease in the tear pH. The possibility of

Table 1. Variation in the mean tear pH among normal and lens wearers. * Shows the approximate time of blinking. The value 0 for the time corresponds to 40 seconds, i.e beginning of pH measurements

Tear pH in Lens Wearers	Tear pH in Normal subjects	Seconds after opening the eye
*6.9	*7.3	*0
7.8	8.0	5
7.5	7.9	10
7.4	7.7	15
7.3	7.7	20
7.4	7.8	25
*6.5	*7.2	*30
7.8	7.9	35
7.4	7.8	40
7.4	7.7	45
7.5	7.7	50
*6.4	* 7.2	*55
7.9	8.5	60

increased blinking, retention of CO_2 and formation of lactate via anaerobic glycolysis due to some hypoxia add together to decrease the tear pH. Although Group IV hydrogel contact lenses are fairly oxygen permeable because of their high equilibrium water contents (EWC = 55–70%), lens type used in this study had the lowest limit of water content. The effect EWC% among different Group IV contact lenses on tear pH is the subject of another investigation performing in our laboratory. It has been estimated that a lens with oxygen transmissibility (Dk/L) of 300 x 10^{-11} (cm/sec) (mL 02/mL x mm Hg) is needed to prevent epithelial intracellular pH (pHi) changes in the open eye. In contrast, lenses with Dk/L as low as 18 x 10^{-9} (cm/sec) (mL 02 / mL mm Hg) can prevent aqueous humor pH changes in rabbits[14].

Table 1 summarize data on tear pH obtained from contact lens wearers and non–lens wearers. To obtain consistent values, pH readings were taken near the steady–state condition, i.e. about 40 seconds after opening of the lids. This also allowed us to separate effects due to contact lens wear from those due to an adapting process related to lid opening. The values are taken as a mean value of the 20–25 volunteers. It can be seen clearly that all values for the pre–corneal tear pH are lower in the case of contact lens wearers.

The lowest mean value obtained in all cases was 6.4 (lens wearers at the time of blinking), and the highest mean value obtained was 8.5 (normal subjects approximately 10 seconds after blinking). In average, the change in pH of control group amounted to 2.2 0.7 pH units/min. Each blink usually resulted in a drop in the pH value. The same pattern was followed in the case of lens wearers, but the pH values were slightly lower in their case (6.9 compared to 7.3, for example, in Table 1).

Our results indicated that the normal pre–corneal tear pH is 7.4–7.6 when measured directly with micro pH electrodes 30–45 seconds after opening the eyelids. It was also shown in this research that the stimulation of tears by wearing contact lenses causes a drop in the pH that turns back to the normal value due to the presence of a buffer system in the tears. It is suggested that contact lenses may stimulate tear secretion in some ways and, therefore, cause more blinking. As a result, a reduction in the value of the pre–corneal tear pH is observed.

It is thought that after opening of the lids and formation of new pre–corneal lacrimal film, the bicarbonate present in the lacrimal fluid is alkalized. With subsequent blinking, the alkaline tear film is replaced by a more acidic one from upper and lower conjunctival sac, and there is a renewed shifting of the pH value toward the alkaline. Using Henderson–Hasselbalch equation, the pH value at complete equilibration of the bicarbonate in the pre–corneal fluid film with partial pressure of CO_2 in the surrounding air can theoretically be calculated as –

$$pH = pK + \log [HCO_3^-]/a \times pCO_2$$

In which, $[HCO_3^-] = 25$ mM/L; pK = 6.1; a = 0.030; $pCO_2 = 1.43$ mm Hg (0.2 vol. % in the air layer adjacent to the skin, according to Rosemann[17]. Thus the calculated pH value in equilibrium is 8.88. This value is in a good agreement with pH measurements of the pre–corneal film when the lids are open for at least 90 seconds.

CONCLUSIONS

Based on the results obtained in this research, it can be concluded that the pH of the human pre–corneal tear fluid depends on the time of equilibration of CO_2 with the surrounding medium. Under normal conditions, an oscillation of the pH value occurs in the pre–corneal tear. In addition, we showed that stimulation of tear secretion by the use of contact lens causes a decrease in the pH of the pre–corneal fluid. Contact lenses may also act as a physical obstacle that may reduce oxygen availability and can cause a decrease in the tear pH. The lack of knowledge about the lens fitting and care systems, especially among very young wearers who consider their lenses as a cosmetic tool rather than a biomaterial that is foreign to the body environment, is a serious problem that may alter many factors in the tear physical and biochemical properties.

The original recording of tear pH among lens wearers and control subjects in inferior fornix of the conjunctiva. The zero second refers to the beginning of the reading (40 seconds after opening of the eye). The pH values were shifted to less alkaline range among contact lens wearer group due in part to stimulation of tears by the lens.

REFERENCES

1. M. G. Bains, F. Cal, H. A. Backman, Adsorption and removal of protein bound to hydrogel contact lenses, *Optometry & Vision Science.* **67(11)**, 807, (1990).

2. E. J. Castillo, J. L. Koenig and J. M. Anderson, Protein adsorption on hydrogels II. reversible and irreversible interactions between lysozyme and soft contact lenses. *Biomaterials,* **6**(3), 110, (1985).

3. R. J. Green, M. C. Davies, C. J. Roberts and S. J. B. Tendler. Competitive protein adsorption as observed by surface plasmon resonance, *Biomaterials.* **20**, 385, (1999).

4. L. Jones, V. Franklin, K. Evans, R. Sariri and B. J. Tighe, Spoilation and clinical performance of monthly vs three monthly Group II disposable contact lenses, *Optometry & Vision Science.* **73(1)**, 16, (1996).

5. L. Jones, K. Evans, R. Sariri, V. Franklin and B. J. Tighe, Lipid and protein deposition of N–vinyl pyrrolidon–containing Group II and Group IV frequent replacement contact lenses, *The CLAO Journal*, **23(2)**, 122, (1997).

6. E. O. Keith, M. Boltz R. Gadh, R. Ghorsriz, D. Mangatt and L. E. Janoff, Adhesion of tear proteins to contact lenses and vials, *Biotechnol Appl Biochem.*, **34**, 5, (2001).

7. W. Norde and J. Lyklema, Why proteins prefer interfaces? *J. Biomaterial Sci. Polymer Edition* , **2(3)**, 183, (1991).

8. R. Sariri and B. J. Tighe, Effect of surface chemistry on protein interaction with hydrogel contact lenses, *Iranian Polymer Journal*, **4(5)**, 259, (1996).

9. F. H. Fischer and M. Wiederholt, The pH dependency of sodium and chloride transport in the isolated human cornea. *Invest Ophthalmol Vis Sci*, **17**, 810, (1978).

10. F. J. Holly, Surface chemistry of tear component analogy, *J. Colloid Interface Sci.*, **49**, 221, (1974).

11. D. M. Maurice, The use of fluorescein in ophthalmological research, Invest. Ophthalmol. **6**, 464, (1967).

12. P. L. Altman and D. S. Dittmer, Physical properties and chemical composition of tears: man, In: Biology data book Sec Ed, *Fed. Am. Soc. Exp. Biol. Bethesda.* Vol: 2033 (1974).

13. L. G. Carney and P. M. Hill, Human tear pH, *Arch. Ophthalmol.* **94**, 821, (1976).

14. C. Giasson and J. A. Bonanno, Corneal epithelial and aqueous acidification during *in vivo* contact lens wear in rabbits, Invest Ophthalmol Vis Sci., **35(3)**, 851, (1994).

15. M. B. Abelson, I. J. Udel and J. H. Weston, Normal human tear pH by direct measurement. *Arch Ophthalmol* **99**, (1981).

16. F. H. Fischer, M. Wiederholt, Human precorneal tear film pH measured by microelectrodes, Graefe's Arch Clin Exp Ophthalmol. **218**, 168, (1982).

17. H. U. Rosemann, In: Landios–Rosemann Lehbuch der phisiologie des Menschen Urban und Schwrzenberg München **1**, 201, (1960).

Accepted : 1.5.2004