

The impacts of contact lenses on the short- and long-term biochemical parameters of tear films and corneal thickness

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ABSTRACT

Introduction: To investigate the effects of long- and short-term use of different types of contact lenses on corneal metabolism and corneal thickness.

Material and Method: The participants were divided into two groups in the study. In the group 1, 20 of the 42 patients were administered a rigid gas-permeable lens (RGPL) with a Dk value of 92x10⁻¹¹ (group 1a), while the remaining wore a soft contact lens with a water content of 38% (group 1b). We then explored their Lactate Dehydrogenase (LDH) levels to evaluate the hypoxic effect on tears in short- (8 hours) and long-term (2nd, 3rd, 5th months) and albumin levels to assess mechanical trauma. In the group 2, the corneal thickness was measured using a Haag-Streit optical pachymeter before and at the 8th hour and 2nd month following the first set of lenses, and LDH and albumin values were simultaneously evaluated in tear.

Results: The results yielded no significant increase in tear LDH and albumin levels in the short- and long-term in both the RGPL and the soft contact lens groups with similar age and sex distribution. In the second part, the corneal thickness measurements resulted in an increase of 5.5% in the RGPL group and 3.63% in the soft lens group at the 8th hour of lens use. However, the groups did not significantly differ by baseline corneal thickness at the 2nd-month follow-up. Similarly, there was no significant increase in LDH and albumin levels in the tear samples of the same group.

Conclusion: The absence of a long-term increase in corneal thickness and no elevated levels of albumin and LDH in tears indicate that contact lenses fit corneal physiology.

Keywords: Lactate dehydrogenase, albumin, contact lens, hypoxia

INTRODUCTION

The idea of correcting optical defects with contact lenses is credited to Leonardo Da Vinci (1). Since then, researchers have been persistently seeking an ideal contact lens suitable for corneal curvature and most compatible with corneal metabolism. While the use of especially rigid gas-permeable lenses (RGPL) persists today (2), soft contact lenses (particularly lenses produced from hydrogel and its derivatives) began to gain popularity in the 1970s (3).

Contact lenses interact with the cornea as well as the tear film layer. A regular human cornea rapidly consumes oxygen under a tight, non-movable lens, which leads to hypoxia (4, 5). Oxygenation of the cornea depends on the oxygen permeability (Dk) value for soft contact lenses with a larger diameter and less mobile compared to RGPL, which allows for tear exchange under the lens and adequate oxygen passage to the cornea due to

its smaller diameter and mobility on the ocular surface (6). Inadequate oxygenation is likely to cause increased corneal edema and corneal thickness (7).

The aqueous component of tears contains many enzymes, and particularly lactate dehydrogenase (LDH) is found in higher concentrations (8). It is thought to be released from conjunctival and corneal epithelial cells in cases of local trauma and damage (9). It also contains proteins with diverse functions in the aqueous component of tears (10). While serum albumin, the protein component of tears, is found in small amounts in unstimulated tears, it is known to increase with mechanical stimulation (11).

Ultimately, we attempted to examine LDH and albumin levels in tears and corneal thickness to explore the impacts of mechanical trauma initiated by short- and long-term use of contact lenses with two different properties.

MATERIAL AND METHOD

In this study, two different study groups at Hacettepe University, Department of Ophthalmology, Contact Lens Unit. between December 1, 2018-August 31, 2019, were evaluated. In this study, two different study groups at Hacettepe University, Department of Ophthalmology, Contact Lens Unit. before 2020, were evaluated. The study was performed as a master thesis and planned as a prospective case-control study. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. The first group included 42 eyes of 42 patients applying for contact lens use or replacement. In the second group, we applied soft contact lenses to 12 of 19 patients who had never used contact lenses before and RGPL to the remaining. We recruited all participants for the detailed anterior and dilated posterior segment examinations and distance visual acuity and intraocular pressure measurements. The study included only those who had no eyelid pathology and ocular surface irregularity, no significant papillary reaction in the upper tarsal conjunctiva, and no chronic blepharitis and had not undergone previous anterior and posterior segment surgery. Yet, we excluded those who had to cease using lenses during the study due to conjunctivitis, keratitis, infectious reasons, and loss of lenses.

In the first group, 20 of the 42 patients were administered a rigid gas-permeable lens (RGPL) with a Dk value of 92×10^{-11} , while the remaining wore a soft contact lens with a water content of 38%. Which contact lens to apply was determined by patients' keratometric values, corneal diameters, and, less decisively, patient preference. We included the left eyes of those wearing lenses in both eyes and those particular eyes of the patients wearing lenses in one eye. We recommended daily chemical care and protein removal once a week for patients receiving soft contact lenses and daily chemical care and protein removal every four weeks for those wearing rigid lenses.

While First group included the patients with soft lenses at group 1a, those with RGPL were grouped in group 1b. Group 1a started to use Cibasoft Blue-vis by Ciba vision company and Optima contact lenses by Bausch and Lomb company, which bear similar water contents, while group 1b was administered Quantum and Aquilla lenses of the same companies. **Table 1** presents lens specifications.

Table 1. Contact lenses and their properties			
Contact lens type	Chemical structure	Dk*	Water content
Cibasoft	HEMA	12×10^{-11}	37.5%
Optima	HEMA		38.5%
Quantum	Fluorosilicone-copolymer	92×10^{-11}	<0.5%
Aquilla	Fluorosilicone-acrylate	143×10^{-11}	

* Oxygen permeability, HEMA: Hydroxyethyl methacrylate

After informing the patients about the study and obtaining their consent and prior to administering the lenses, we collected 20-50 μ l tears in heparin-free glass capillary tubes from the marginal tear meniscus close to the outer canthus of the lower lid upon protecting the cornea and conjunctiva. The samples were stored at +4°C and analyzed within 3 days at the latest. After the first application, tears were collected at the 8th hour of the first application and the 2nd, 3rd, and 5th months by the same method.

In Second group, we divided the patients into two (Groups 2a and 2b) and measured corneal thickness using a Haag-Streit optical pachymeter and simultaneously evaluated LDH and albumin values before lens application and at the 8th hour and 2nd month after the first set of lenses. While oxygen permeability 143×10^{-11} Aquilla RGPCL was applied to Group 1a, Optima soft KL with 38.5% water content was applied to Group 2a. LDH and albumin levels of the samples were measured at Hacettepe University, Faculty of Medicine, Department of Biochemistry.

Statistical Analysis

We performed the significance test of the difference between two pairs and the Wilcoxon Signed Rank Test for within-group comparisons and the significance test of the difference between the two means for between-group comparisons. All analyses were performed on the Statistics Package for Social Sciences (SPSS), and a p-value < .05 was accepted as statistically significant.

RESULTS

While 20 (90.9%) of the 22 soft lens wearers (Group 1a) were females, 15 (75%) of the RGPL wearers (Group 1b) were females. We found the mean ages of the groups to be 25 ± 1.08 years and 28.7 ± 1.98 years, respectively. The groups did not significantly differ by age ($t=1.65$, $p>0.05$). Among soft lens wearers, 59.1% used Cibasoft lenses, while 40.9% used Optima lenses. In the other group, 65% used Quantum lenses, while 35% used Aquilla lenses.

Tear samples taken before contact lens applications were presented as control values. The mean baseline LDH and albumin levels were measured as 565.51 ± 823.90 U/L and 0.88 ± 1.39 gr/dL, respectively, in Group 1a. They were found to be 666.69 ± 945.62 U/L and 0.81 ± 0.61 gr/dL, respectively, in Group 1b. We could not find any statistical difference between the groups by baseline LDH and albumin levels ($t=0.37$, $p=0.715$ and $t=0.22$, $p=0.825$, respectively).

The comparison of the groups by LDH and albumin levels after eight hours of contact lens use is presented in

Table 2. The other tables (**Tables 3, 4, and 5**) demonstrate the comparisons of the groups by LDH and albumin levels after 2 months, 3 months, and 5 months of contact lens use. Accordingly, we found that the groups' baseline LDH and albumin levels did not significantly differ from the values after the 8 hours, 2 months, 3 months, and 5 months of contact lens use ($p>0.05$).

In the second part of the study, we found the mean ages of 12 patients using soft contact lenses in Group 2a and 7 patients using RGPL in Group 2b to be 25.08 ± 4.66 years and 25.08 ± 7.65 years, respectively. Yet, there was no significant difference between the groups by age. While there were 4 females (57.1%) in Group 2a, Group 2b hosted 10 (83.3%) females. We discovered LDH levels in Group 2a before lens application and at the 8th hour and 2nd month of lens use to be 797.29 ± 977.34 U/L, 733.17 ± 1017.94 U/L, and 916.84 ± 1079.78 U/L, respectively. In the same group, albumin levels were noted as 0.45 ± 0.26 g/dL, 0.30 ± 0.13 g/dL, and 0.36 ± 0.32 g/dL, respectively. In Group 2b, the mean LDH levels before lens application and at the 8th hour and 2nd month of lens use were found to be 330.61 ± 439.46 U/L, 367.93 ± 367.20 U/L, and 453.63 ± 260.93 U/L, respectively. In the same group, albumin levels were concluded to be 0.41 ± 0.34 g/dL, 0.42 ± 0.28 g/dL, and 0.27 ± 0.22 g/dL, respectively.

dL, respectively. Accordingly, we could not conclude a significant difference between LDH and albumin levels of the groups.

On the other hand, the corneal thickness was measured as 0.540 ± 0.02 μ m at baseline, 570 ± 0.03 μ m at the 8 hours of lens use, and 0.540 ± 0.02 μ m at the 2 months of lens use in Group 2a. In Group 2b, it was 0.530 ± 0.02 μ m at baseline, 550 ± 0.03 μ m at the 8 hours of lens use, and 0.550 ± 0.02 μ m at the 2 months of lens use. In both groups, the corneal thickness was significantly higher after 8 hours of lens use (Group 2a: $p=0.042$; Group 2b: $p=0.021$). However, there was no significant difference in the corneal thickness in Group 2a at baseline and the 2 months of lens use. It was also the case in Group 2b at the 8 hours and 2 months of lens use (**Figure 1**).

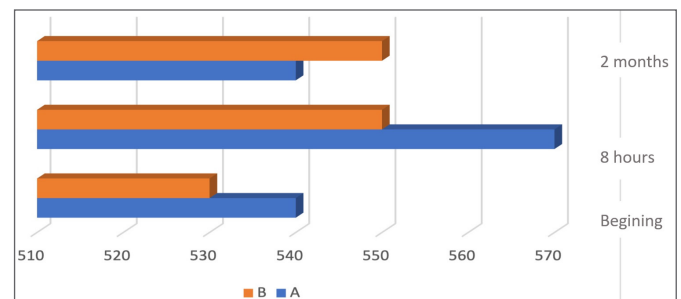


Figure 1. Corneal thickness change in group 2a and group 2b at baseline and after 8 hours and 2 months of lens use

Table 2. Tear LDH and albumin levels in the groups after 8 hours of lens use						
	LDH 1 (U/L)	LDH2	p	Alb1 (gr/dl)	Alb2 (gr/dl)	p
Group 1a	565.51±823.90	507.68±684.73	p=0.49	0.88±1.39	0.78±0.69	p=0.77
Group 1b	666.69±945±62	612.68±806.52	p=0.75	0.81±0.61	0.66±0.39	p=0.37
P		p=0.65			p=0.52	

LDH: Lactate dehydrogenase, Alb: Albumin

Table 3. Tear LDH and albumin levels in the groups after 2 months of lens use						
	LDH 1 (U/L)	LDH2	p	Alb1 (gr/dl)	Alb2 (gr/dl)	p
Group 1a	565.51±823.90	455.15±439.45	p=0.49	0.88±1.39	0.64±0.74	p=0.46
Group 1b	666.69±945±62	603.59±738.54	p=0.69	0.81±0.61	0.64±1.09	p=0.59
P		p=0.44			p=0.99	

LDH: Lactate dehydrogenase, Alb: Albumin

Table 4. Tear LDH and albumin levels in the groups after 3 months of lens use						
	LDH 1 (U/L)	LDH2	p	Alb1 (gr/dl)	Alb2 (gr/dl)	p
Group 1a	565.51±823.90	407.21±417.51	p=0.31	0.88±1.39	0.54±0.48	p=0.27
Group 1b	666.69±945±62	313.13±241.24	p=0.12	0.81±0.61	0.68±1.03	p=0.65
P		p=0.37			p=0.56	

LDH: Lactate dehydrogenase, Alb: Albumin

Table 5. Tear LDH and albumin levels in the groups after 5 months of lens use						
	LDH 1 (U/L)	LDH2	p	Alb1 (gr/dl)	Alb2 (gr/dl)	p
Group 1a	565.51±823.90	560.74±599.25	p=0.97	0.88±1.39	0.44±0.23	p=0.17
Group 1b	666.69±945±62	1062.7±1811.8	p=0.25	0.81±0.61	0.57±0.61	p=0.42
P		p=0.25			p=0.39	

LDH: Lactate dehydrogenase, Alb: Albumin

DISCUSSION

Various changes (e.g., hyperemia, epithelial defect, keratitis, epithelial microcyst formation in the long term, hypoesthesia, and vascularization in the cornea) may be observed on the avascular cornea and ocular surface following a contact lens application (12). Nevertheless, it should be noted that aerobic metabolism shifts to anaerobic destruction, which is likely to cause alterations in enzymes and biochemical parameters even in typically observed corneas (13).

LDH found in tears appears in a higher concentration than other enzymes and is rooted in the ocular surface. Therefore, it is thought to be a marker of epithelial damage (9,14). A previous study concluded that the use of contact lenses reduces the hemidesmosomal complex and reported that a 10-20 times higher isoenzyme level of LDH than its serum level supports the hypothesis that LDH is not serum-derived but increases with tissue damage (15). Van Haeringen (16) reported that the activity of LDH in tears is higher than other enzymes and ranges between $0.63\text{-}5.57 \times 10^3$ U/L. We also detected the baseline LDH levels within the mentioned range. Fullard et al. (17) stated that LDH enzyme activity, known to be sensitive to hypoxia, peaks upon waking in the morning. Therefore, we obtained all samples in the afternoon to eliminate this effect. In our study, we found no significant change in LDH levels in the soft lens and RGPL groups after the short- and long-term lens use. We think that choosing an RGPL with a Dk of 92% and a soft contact lens with a water content of 38% may have prevented the development of hypoxia.

It was previously shown that serum albumin is in trace amounts in unstimulated tears under typical conditions but increases in tear concentration in any mechanical damage (18). Josephson et al. also found higher levels of albumin, beta globulin, and transferritin concentrations in tears taken after rubbing the eyes for 3 minutes than their serum levels and in the other non-traumatized eye. (19). In addition, it is known that some of the albumin in tears passes through the lacrimal gland, while some passes through the superficial conjunctival capillaries (20). In this case, the amount of tear protein would increase with the increase in the permeability of the limbal vessels with a mechanical effect, which is particularly true with tightly applied soft contact lenses.

In their study, Ichijima et al. (21) did not conclude any increase in the amount of tear protein after the long-term use of RGPL. Overlapping with this finding, we found no tear protein increase in both the soft lens and RGPL groups in the short- and long-term. Therefore, we can assert that the lenses used in appropriate sizes do not cause severe mechanical trauma to the ocular surface.

In clinical practice, it is now well established that corneal thickness is a useful indicator of ocular health, as corneal transparency is expected to decrease with increasing corneal thickness (22). Although there are studies that indicate that corneal thickness is not affected by contact lens wear, overall, a minor edema can be tolerated if contact lens wear is maintained on a daily basis, and generally only slight increases in CCT are observed in adapted contact lens wearers (22,23). It is needed to make the measurement on the central cornea to get a clear idea. In our study, there was an increase of 5.5% in the RGPL group (Group 1a) and 3.77% in the soft contact lens group (Group 1b) after 8 hours of contact lens application; however, there was no significant difference between the groups. After 2 months of contact lens use, the thickness increase continued in Group B, but it was reduced to the baseline level in Group A. It is known that RGPLs take a long time to be adapted to and cause increased lacrimation due to discomfort. Increased lacrimation, on the other hand, decreases osmolarity and increases fluid passage to the cornea. In this case, it was previously shown that corneal thickness increases by 2-4% (24). Overlapping with this finding, we discovered the increase in corneal thickness was higher in the RGPL group, but it returned to the baseline level in the 2nd month. However, the increase in both groups cannot be attributed to hypoxia since it is less than the 4% nocturnal increase in corneal thickness in the soft CL group. We believe that the patients' regular use of the lenses may have contributed to the increase in corneal thickness initiated by the contact lenses to remain within the physiological limits.

CONCLUSION

Overall, contact lenses may increase corneal thickness within physiological limits but do not cause a hypoxic effect to impair corneal physiology. No deterioration in the biochemical values of tears in the short- and long-term use of the lenses may also support the thesis above. The increase in corneal thickness can further be kept within physiological limits thanks to advanced production technologies and high oxygen permeability lenses. Further research may conclude more comprehensive findings with lenses with different material properties.

ETHICAL DECLARATIONS

Ethics Committee Approval: Retrospective ethics committee approval is not required for articles which was produced from master's/doctorate thesis before 2020.

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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