Effect of Extrinsic Controls on Blinking and Tear Film Stability among Soft Contact Lens Wearers

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Abstract

Purpose: To study the effect of extrinsic controls on blinking and tear film stability among the adapted soft Contact Lens (CL) wearers while performing varying tasks that require different amounts of visual concentration. Aim: To investigate the changes in blink rates, completeness of the blink and tear stability among adapted soft CL wearers while performing the task of listening music and playing a game. Methods: The Demographic Questionnaire and The Contact Lens Dry Eye Questionnaire (CLDEQ) were completed by 50 normal adapted contact lens wearers aged 12-35 years. TBUT was measured for both eyes non-invasively with keratometer before and after the tasks, with and without contact lenses. Measurements of blinking were obtained with a video camera while subjects listened to music and played a game on laptop each for about 5 minutes with and without contact lenses. Blink rate (BR) and Blink Amplitude (BA) were determined manually from these video recordings. Results: With the game compared to music, IBI was significantly longer and the BR and BA significantly decreased without CLs (p ≤ 0.001). Also with CLs, IBI was significantly longer and the BR and BA significantly decreased with the game compared to music (p < 0.001). The TBUT was significantly correlated with the CLDEQ scores (Pearson r= -0.464, p < 0.05). TBUT was correlated with the BA but it was statistically insignificant (Pearson r= 0.110 and 0.126, p < 0.05) Conclusion: During tasks requiring concentration, the IBI increased (blink rate decreased) and many blinks were incomplete without CLs. With CLs, tear film instability increased. Blinking frequency also increased, but it remained high when subjects played the game, and symptoms of ocular irritation increased.

Key words: Blink Rate (BR), Blink Amplitude (BA), Tear-Film Break-Up Time (TBUT), Inter-Blink Interval (IBI)
Introduction

The tear film protects and nourishes the ocular surface. The tear-film structure and behavior are altered as a result of inserting a contact lens into the eye. (3) Tears are a complex solution, where individual constituents interact in a dynamic environment to produce a stable protective film. The introduction of a contact lens inhibits the creation of an adequate tear film and potentially changes the homeostasis of the tear film at the surface of the contact lens and surrounding areas.

An alteration in the blink reflex may also be associated with an increase in tear film evaporation, especially if the inter-blink period is prolonged. The nature of a contact lens material may lead to interactions with the lipid layer (through deposition), which may reduce the stability of the lipid layer of the pre-lens tear film, which may lead to increased tear film evaporation and contact lens dehydration. (5)

A healthy human is expected to show periodic blinks, making a brief movement of eyelids. It has been established that efficient blinking plays an important role in ocular surface health during contact lens wear and for improving contact lens performance and comfort. Inefficient blinking during contact lens wear may be related to a low blink rate or incomplete blinking and can often be the reason for dry eye symptoms or ocular surface staining. Contact lens wear leads to alterations in the blink reflex, which in turn, could lead to alterations in the tears heading through the excretory portion of the lacrimal system.

Theories about an association between blink frequency and tear-film break up have been proposed. It is suggested that the sensory nerves in the cornea may detect localized changes in tear film stability prior to tear film break up which thereby trigger an involuntary blink. (19)(20)(21)(22) Complete blinking is important in the health of ocular surface. It is therefore important to understand how various factors may influence the natural blink rate and completeness.

The aim of this study is

- To investigate the effect of extrinsic controls on blinking by examining blink rates and completeness of the blink among adapted soft CL wearers while performing varying tasks that require different amounts of visual concentration like listening music and playing the game

- To investigate the changes in the tear film stability with tasks performance with and without contact lenses.

### Methodology

#### Subjects

This study was conducted at a tertiary eye care hospital in Ahmedabad from August 2012 to November 2013. 50 adapted soft contact lens wearers were included in this study. A routine eye-examination including visual acuity assessment and slit-lamp evaluation was carried out to determine their suitability for the study and ensure that their eyes were healthy. All subjects had worn soft CLs (hydrogel or silicone hydrogel) for 4 or more days a week for at least 3 months. Subjects did not wear their CLs for at least 12 hours before participating in the experiment. On the day of testing, subjects

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<table>
<thead>
<tr>
<th>Inclusion Criteria:</th>
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<tr>
<td>• Age group from 12-35 years</td>
<td>• Any ocular pathology or infection</td>
</tr>
<tr>
<td>• Adapted soft contact lens wearers (≥ 6 months)</td>
<td>• Any systemic disease</td>
</tr>
<tr>
<td>• Visual Acuity: distance ≥ 6/12, near ≥ N8</td>
<td>• Subjects on topical ophthalmic medications or systemic medications</td>
</tr>
<tr>
<td>• Conventional and monthly disposable contact lens wearers</td>
<td>• Occasional soft contact lens wearers</td>
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<td>• Daily disposable contact lens wearers</td>
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were instructed to bring their habitual lenses with them, which would be inserted later during the experiment. Informed consent was obtained from each subject before beginning the study.

All subjects completed two questionnaires at the beginning of the study, the Demographic Questionnaire (DQ), which asked general questions about age, gender, and occupation and the Contact Lens Dry Eye Questionnaire (CLDEQ-8) which determined the frequency and intensity of habitual ocular surface symptoms while using contact lenses over a 2-week recall period.

Subjects were told that the experiment monitored their tear film while performing different tasks. Blinking was not mentioned to preclude self-conscious unnatural blinking during testing.

Tear Film Break-Up Time (TBUT)

Before beginning the actual tasks, the tear break-up time was measured non-invasively for each eye with the help of Bausch and Lomb Keratometer. The time taken (in seconds) for the appearance of first dry spot in the form of distortion of clear, crisp mires immediately after the complete blink was considered as the tear-break up time. It was also measured again after the completion of the task.

Task Procedures

Subjects were asked to wear their current spectacles to begin with the tasks. Subjects were seated comfortably behind a laptop (DELL STUDIO 15 1535) which captured a video measuring the blink rate and upper lid movement during the blink, while subjects performed two tasks, both with and without contact lenses (with spectacle correction). Video was captured at a rate of 30 frames/second. The frame width was 640 and the resolution was 768x1366 pixels.

The first task consisted of listening to the music of subject’s own choice for 5 minutes while looking nearly straight ahead with minimal head movement.

The second task consisted of playing a game “Space Bubbles” on the laptop for 5 minutes. Patient was trained regarding how to play it before the actual task to avoid conscious eye movements.

After the completion of two tasks, the tear-film break up time was measured again with keratometer.

Procedures with Contact Lenses

Next, subjects were asked to wear their contact lenses. 10-15 minutes were given for adaptation of lenses. Again the same procedure was repeated. Tear break-up time was measured non-invasively over the contact lenses for both eyes. The two tasks of listening music and playing game were performed similarly. The tear break-up time was again measured over contact lenses after completion of tasks.

All subjects were tested in the same order: listening music with glasses, playing game with glasses, listening music with CL and playing game with CL. This was to ensure that baseline (no CL) testing was done before any lenses were placed on the eye.

Blink Analysis

Videotapes were later analyzed by visual inspection with decreased speed of 0.4x. Blinks were counted manually and the Blink Amplitude (in %) was evaluated manually on the basis of the ocular surface area covered by the upper eyelid for the 5 minutes of both tasks. Blink Rate for 1 minute and average Blink Amplitude were calculated from this. Inter-blink interval (IBI) was calculated from the blink rate.

Data Analysis

The TBUT was compared before and after the task using a paired T test. The BA and IBI were compared among tasks using a paired T test. Spearman correlation coefficient was used to determine whether symptoms were correlated with AB or blink parameters.

RESULTS
Refractive Error

All subjects but 1 included in the study is myopic. The mean refractive error in OD is -3.69 ± 2.40 diopters while the mean refractive error for OS in these subjects is -3.68 ± 2.35 diopters.

TBUT with Spectacle and Contact Lenses

Table 1 shows the mean values of TBUT for right eye before and after the task of listening music and playing game with spectacle and contact lens. The p value calculated is < 0.0001 which is considered extremely significant.

<table>
<thead>
<tr>
<th>Tear-film Break-Up Time (in seconds)</th>
<th>OD (before task)</th>
<th>OD (after task)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Spectacle</td>
<td>11.92±4.18</td>
<td>9.6±3.52</td>
</tr>
<tr>
<td>With Contact Lens</td>
<td>8.14±2.92</td>
<td>6.52±3.69</td>
</tr>
</tbody>
</table>

Table 1

Blink Pattern with Spectacle and Contact Lenses

Table 2 shows the mean values of IBI, BR and BA with glasses and CL while listening to music and playing the game. The p value calculated is < 0.0001 for IBI, BR and BA which is considered extremely significant.

<table>
<thead>
<tr>
<th>With Spectacle and CL</th>
<th>Music</th>
<th>Games</th>
<th>Music</th>
<th>Games</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBI</td>
<td>4.39±1.98</td>
<td>10.05±4.32</td>
<td>3.008±1.149</td>
<td>4.702±2.52</td>
</tr>
<tr>
<td>BR (blink per minute)</td>
<td>16.5±7.32</td>
<td>7.84±5.56</td>
<td>23.4±10.01</td>
<td>15.7±6.69</td>
</tr>
<tr>
<td>BA (in percentage)</td>
<td>91.69±2.84</td>
<td>87.4±3.87</td>
<td>93.39±4.01</td>
<td>90.41±5.28</td>
</tr>
</tbody>
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Table 2

The CLDEQ-8 scores for these 50 subjects ranged from 6 to 27 with a mean score of 16.56 ± 5.36. The CLDEQ scores were significantly correlated with the TBUT values (Pearson r= -0.464, p < 0.05). The CLDEQ scores were also correlated with the BA but it was statistically insignificant (Pearson r= 0.110 and 0.126, p < 0.05).

Discussion

In this study the BR decreased when playing a computer game that required concentration, thus supporting the idea that internal controls slow blinking to enhance attention. When subjects in this study wore their habitual CLs, blinking significantly increased. This suggests that the wearing of soft CLs, even when fully adapted, provides enough extrinsic ocular surface or lid stimulation to override internal controls and maintain a relatively rapid rate of blinking.

Decreased TBUT over the lens was also significantly associated with increased habitual symptoms of dry eye and a more severe self-assessment of dry eye in this study. The less tear film stability over a CL, compared to the corneal surface, may be implicated in providing surface stimulation for blinking. Whether this stimulus is derived from the back surface of the lens against the cornea, the action of the lid acting as a wiper over the CL surface, or some other stimulus is not known.

Another possibility is that transiently blurred vision in the interblink period triggers blinking. Complaints of transient, blurry vision are common among CL wearers and dry eye patients, and visual disturbances have recently been added to the definition of dry eye. Incomplete blinking was common among subjects in this study, which could have contributed both to overall lens dryness and visual effects. Thus, the nature of the stimulus for
increased blinking provided by a CL remains difficult to identify.

The fullness of the blink is a parameter not often investigated but does appear to be modified by attention and visual task. In this study, when subjects played the video game, blinking was much less complete, whether wearing CLs or not. This suggests that internal controls over blinking act to reduce both the BR and BA to minimize task interruption by the upper lid, partial blink may be more stable than following a full blink among dry eye patients; thus, partial blinks could be advantageous under some condition.

In the present study agrees to Jansen et al, which also showed without CLs, IBI was significantly longer and BA significantly decreased with the game compared to music (p < 0.0001 for IBI and BA). With CLs, again IBI was significantly longer and BA significantly decreased with the game compared to music (p < 0.0001, for IBI and BA).

In the present study, two tasks were included: listening music and playing the game. In comparison with BR while listening music (16.5 ± 7.3 blinks/min), the BR significantly decreased during laptop use for playing a game (BR=7.84 ± 5.56 blinks/ min) (p<0.0001). Thus it correlated with the other conducted studies.

In the present study, TBUT values decreased after contact lens insertion which supported the study conducted by Thai Lee Choon et al. They concluded that all soft contact lens materials significantly and adversely affect tear physiology by increasing the evaporation rate and decreasing tear thinning time.

**Conclusion**

From this study, it is concluded that during tasks requiring concentration, the IBI increased (blink rate decreased) and many blinks were incomplete without CLs. With CLs, tear film instability increased. Blinking frequency also increased, but it remained high when subjects played the game, and symptoms of ocular irritation increased. This suggests that wearing soft CLs, even when fully adapted, provides enough extrinsic ocular surface stimulation to override internal controls and affect blink parameters.

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