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Effects of Prolonged Reading on Dry Eye

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Purpose: To demonstrate the effects of prolonged silent reading on tear film and ocular surface parameters.
Design: Prospective, observational clinical study.
Participants: A total of 177 patients with dry eye and 34 normal controls aged 50 years and older.
Methods: After evaluating symptoms using the Ocular Surface Disease Index (OSDI) questionnaire, the following tests were performed in consecutive order: automated noninvasive tear break-up time (TBUT), surface asymmetry and regularity indices, Schirmer's testing without anesthesia, corneal staining using fluorescein, and conjunctival staining using lissamine green. The participants were then asked to read a 30-minute validated passage silently. The tests were repeated after the reading task.
Main Outcome Measures: Changes in tear film and ocular surface parameters after reading.
Results: All parameters, with the exception of surface asymmetry index, worsened after the reading task in patients with dry eye and in controls. The worsening reached a statistical significance for corneal and conjunctival staining in the dry eye group ($P < 0.001$) and for corneal staining in the control group ($P < 0.01$). At baseline, OSDI scores correlated only with corneal and conjunctival staining scores ($r = 0.19$, $P = 0.006$ and $r = 0.27$, $P < 0.001$). Among postreading measurements, baseline OSDI scores correlated with TBUT ($r = -0.15$, $P = 0.03$) in addition to corneal and conjunctival staining ($r = 0.25$, $P < 0.001$ and $r = 0.22$, $P = 0.001$). Changes in TBUT and Schirmer's test correlated significantly with their respective baseline values ($r = -0.61$, $P < 0.001$ and $r = -0.44$, $P < 0.001$), indicating that the more unstable the tear film and the lower the aqueous tear secretion, the worse they became after the prolonged reading task. Worsening in corneal staining directly correlated with the baseline conjunctival staining ($r = 0.17$, $P = 0.02$) and surface regularity index ($r = 0.21$, $P = 0.01$).
Conclusions: Evaluating tear film and ocular surface parameters at rest may miss clinical findings brought about by common everyday tasks such as reading, leading to discordance between patient-reported symptoms and clinician-observed signs. Quantifying dry eye after visually straining activities such as prolonged silent reading may help better understand patient symptomatology. *Ophthalmology 2018;■:1–7 © 2018 by the American Academy of Ophthalmology*

Modern lifestyle requires increasingly demanding visual tasks such as book reading for leisure or use of electronic devices for work-related productivity.[1] Previous questionnaire-based studies indicated self-reported difficulty with reading as one of the most common symptoms of dry eye, suggesting that reading difficulty is an important component of how dry eye affects the quality of life of affected patients.[2-6] In fact, symptoms after sustained reading are not unique to patients with dry eye, and even healthy individuals with no prior dry eye diagnosis experience visual symptoms after prolonged reading.[7,8] Computer work is particularly problematic, with prolonged use of computer displays causing significant worsening in dry eye symptoms.[6,8-10]

One shortcoming with regard to the diagnosis and treatment of dry eye has been the absence of objective measurable parameters that can help quantify the disease state and evaluate the efficacy of treatments. As clinicians who care for patients with dry eye, we are aware of the lack of correlation between patient-reported symptoms experienced on an everyday basis and objective findings as currently measured in the clinic. For example, many patients with dry eye with perfect visual acuity and mild corneal staining report that they are unable to read comfortably because of their symptoms. We hypothesized that quantifying dry eye at rest may miss clinical findings brought about by common daily tasks such as reading. Therefore, in this study, we aimed to quantify the objective dry eye parameters measured at baseline and after sustained reading, and correlate them with baseline patient symptoms.

Methods

The study protocol was approved by the Johns Hopkins University and the Rochester University Institutional Review Boards in accordance with the Declaration of Helsinki, and the study procedures were performed according to Health Insurance Portability and Accountability Act. New and return patients with dry eye, older than 50 years of age and with a binocular visual acuity of 20/25 or better, who presented to the Ocular Surface Diseases and Dry Eye Clinic at the Wilmer Eye Institute, the Johns Hopkins University (Baltimore, MD), and the Dry Eye Clinic at the Flaum Eye Institute, Rochester University (Rochester, NY) were identified by a study coordinator. Patients with self-reported illiteracy or language problems, contact

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lens wearers, and patients who had any ocular surgery within the preceding 3 months were not considered. Patients who did not take any prescription eye drops (including topical cyclosporine, steroids, and antiglaucoma eye drops) within 30 days of the study visit were consented by a study investigator. Individuals who were using over-the-counter drops (including artificial tears) were asked to refrain for 24 hours before the study visit. Similarly aged accompanying friends or family members, as well as healthy volunteers, with no history of dry eye or current dry eye symptoms, or other ocular diseases requiring topical treatment were recruited as controls at both sites.

First, the Ocular Surface Disease Index (OSDI) questionnaire was administered to evaluate dry eye−related symptoms. A total OSDI score and 3 subscores—(1) ocular symptoms subscore (questions 1 to 5), (2) vision-related function subscore (questions 6 to 9), and (3) environmental triggers subscore (questions 10 to 12)—each ranging from 0 to 100 were calculated as previously described.[11]

The following tests were then administered to both eyes in the order listed with at least 5-minute breaks in between. First, the Tear Stability Analysis System incorporated into the Tomey Top-Ref-Keratometer RT-7000 (Tomey, Phoenix, AZ) corneal topography machine was used to measure noninvasive tear break-up time (TBUT). Values greater than 3.0 seconds were considered normal as previously recommended.[12] The surface irregularity indices (surface asymmetry index and surface regularity index) were measured by the Tomey TMS-4 videokeratoscopy (Tomey, Waltham, MA). Greater values represent greater irregularity of the ocular surface.[13] Finally, Schirmer's testing was performed without anesthesia using sterile strips (Tear Flo; Sigma Pharmaceuticals, Monticello, IA), and the length of paper wetting was measured after 5 minutes.

Ocular surface staining was graded according to the Sjögren's International Collaborative Clinical Alliance grading system.[14] Conjunctival staining was evaluated first, using a neutral density filter over the light source immediately after instillation of lissamine green dye (Green-Glo; HUB Pharmaceuticals, LLC., Rancho Cucamonga, CA). The nasal and temporal conjunctiva, within the interpalpebral fissure, were graded separately with a maximum score of 3 for each area. The area where the Schirmer's test strips were placed was not taken into consideration when grading the temporal conjunctiva. Corneal staining was evaluated using the cobalt blue filter at least 2 minutes after instillation of fluorescein dye (Ful-Glo; Akorn, Inc., Lake Forest, IL). The maximum possible fluorescein score (the punctate epithelial erosions grade plus any extra points for modifiers [central corneal staining, confluent staining, and filaments]) was 6 for each cornea. The total possible maximum ocular staining score, derived by summing the corneal and conjunctival scores, was 12 for each eye.[14]

At this point, participants were given a standardized, validated reading task consisting of a 7200-word story to be read silently for 30 minutes or until finished.[15,16] Participants were allowed to wear their habitual correction for near vision. Reading was performed in a 12 feet wide by 17 feet long room with standardized lighting between 400 and 600 lux[15] and environmental conditions (relative humidity level between 30% and 50% and temperature level between 73°F and 75°F).

After completion of the reading task, the following tests were repeated as described previously in this order: noninvasive TBUT, the irregularity indices (surface asymmetry index and surface regularity index), Schirmer's test, conjunctival lissamine green staining, and corneal fluorescein staining.

Statistical Methods

Measurements only from the right eye were used for all analyses. A *t* test was used to compare the continuous variables, and a chi-square test was used to compare categoric variables between groups. A paired *t* test was used to compare before and after observations within the study groups. Pearson and Spearman's rank correlation coefficients were used to analyze the associations between variables. Values of $P < 0.05$ were considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics version 23 (IBM Corp., Armonk, NY).

Results

A total of 224 participants completed the study-related procedures. Thirteen participants who finished the reading task in less than 20 minutes (8 patients with dry eye and 5 controls) were excluded. The remaining 211 patients (177 patients with dry eye and 34 controls) were included in the analyses.

Table 1 displays the baseline clinical characteristics in each group. There were no significant differences between patients with dry eye and controls with regard to age or sex. Mean duration of reading was 28.3 minutes (20.6−31.6 minutes; standard deviation, 2.2) in the dry eye group and 27.7 minutes (20.2−30.5 minutes; standard deviation, 2.8) in the control group ($P = 0.15$). At baseline, patients with dry eye had a higher mean symptom score and objective clinical parameters compared with controls except for the surface regularity indices (Table 1).

All measured parameters worsened in the dry eye group and in the controls (with the exception of surface asymmetry index); however, not all of these changes were statistically significant (Table 2). The worsening reached a statistical significance for corneal and conjunctival staining in patients with dry eye ($P < 0.001$ and $P = 0.001$, respectively) and for corneal staining in the control group ($P = 0.003$).

Table 3 displays correlations between OSDI scores and tear film and ocular surface parameters at baseline, postreading, and the change from baseline. The total OSDI score and all 3 OSDI subscores (ocular symptom, vision-related function, and environmental triggers) correlated significantly with baseline corneal and conjunctival staining. The strongest correlation was observed between the environmental triggers subscore and baseline temporal conjunctival staining (r = 0.32, $P < 0.001$). Although there was no significant correlation at baseline, the TBUT measured after the prolonged reading test correlated with the baseline total OSDI score as well as ocular symptom and environmental triggers subscores. In addition, correlations between all OSDI scores and the corneal staining became more robust after the reading task. When correlations between baseline OSDI scores and worsening of tear film or ocular surface parameters after reading were analyzed, the increase in corneal staining correlated well with the total OSDI score and environmental triggers subscore. Among the 3 modifiers of corneal staining (presence of central staining, confluent staining, and presence of filaments), confluent staining at baseline significantly correlated with total OSDI score and all 3 subscores. Central staining was found to correlate with all OSDI scores not at baseline but postreading. Moreover, correlations between confluent staining and OSDI scores became stronger after reading.

Table 4 displays correlations between baseline tear film parameters and changes from baseline after the sustained reading task. Changes in TBUT and the Schirmer's test correlated significantly with their respective baseline values, indicating that the more unstable tear film and the lower aqueous tear secretion, the worse they became after the prolonged reading task. Of note, worsening in corneal staining directly correlated with the baseline conjunctival staining and surface regularity index.

Discussion

This study demonstrates that prolonged reading causes significant alterations on the ocular surface not only in