DOI: 10.14744/eer.2023.77487
Eur Eye Res 2024;4(1):63–67

EUROPEAN EYE RESEARCH

ORIGINAL ARTICLE

The influence of chewing gum activity on tear production: A prospective study of anterior segment optical coherence tomography

Hakan Ozturk, Hasan Aytogan, Emre Ayintap

Department of Ophthalmology, University of Health Sciences, Tepecik Training and Research Hospital, Izmir, Türkiye

Abstract

Purpose: At present, drug treatments are composing the majority of dry eye therapies. However, considering the side effects of drugs, there has been increasing interest in novel non-drug treatment options, and these new treatments have been researching ways of tear production. Therefore, we aimed to investigate the role of chewing gum on tear-meniscus parameters and blinking rate with objective and quantitative methods.

Methods: Sixty eyes of 30 healthy volunteers' tear-meniscus height (TMH), tear-meniscus depth (TMD), and tear-meniscus area (TMA) were acquired with anterior segment-optical coherence tomography. Tear-meniscus measurements were performed before and during chewing gum; at 15 and 30 min. Blinking rates were also recorded both before and during chewing gum for 5 min.

Results: TMH, TMD, and TMA values at 15 and 30 min of chewing gum were significantly higher than those values before chewing gum ($p<0.001$). TMH, TMD, and TMA values at 15 min of chewing gum were similar to those values at 30 min of chewing gum ($p>0.05$). Blinking rate during chewing gum was significantly higher than that value before chewing gum ($p<0.001$).

Conclusion: To the best of our knowledge, this was the first study demonstrating that chewing gum increased tear-meniscus parameters and blinking rate at acute phase of chewing with objective, quantitative, and non-invasive methods. Chewing gum is cheap, sustainable, and easy to reach. In addition, it is not a drug, and there is no risk of drug-related side effects. According to our outcomes, we thought that chewing gum might improve dry eye-related complaints by increasing tear production and blinking rate.

Keywords: Blinking; chewing gum; optical coherence tomography; tear meniscus; tear production.

Dry eye disease (DED) has been defined as a multifactorial ocular surface disorder characterized by a loss of tear film homeostasis, and accompanied by ocular symptoms, in which tear film instability and hyperosmolarity, ocular surface inflammation and damage, and neurosensorial abnormalities play etiological roles.[1] The prevalence of DED was stated in a range between 5% and 50% at the Dry Eye Workshop Study II (DEWS II) by the Tear Film and Ocular Surface Society.[2] Nowadays, the use of digital devices is increasing for various reasons such as working,

Cite this article as: Ozturk H, Aytogan H, Ayintap E. The influence of chewing gum activity on tear production: A prospective study of anterior segment optical coherence tomography. Eur Eye Res 2024;1:63-67.

Correspondence: Hakan Ozturk, M.D. Department of Ophthalmology, University of Health Sciences, Tepecik Training and Research Hospital, Izmir, Türkiye
E-mail: opthdrhakan@hotmail.com
Submitted Date: 07.11.2023 **Revised Date:** 10.12.2023 **Accepted Date:** 13.12.2023 **Available Online Date:** 20.03.2024

shopping, chatting, playing games, or surfing the internet. Increasing visual display terminal (VDT) (e.g., smartphone, computer, and tablet) usage was also reported to be with the increasing DED in individuals.[3,4] In addition, VDT usage has been found to reduce spontaneous blinking, which is essential for a normal tear distribution on the ocular surface.[5-7]

Most of the diagnostic and therapeutic modalities in DED have focused on the tear film because a stable tear film is required for a healthy refractive corneal surface.[8,9] At present, artificial tears, ointments, and anti-inflammatory medications are composing the majority of dry eye therapies.[8] However, novel treatment options have been researching the ways of tear production by nasolacrimal neurostimulation.[10-12] In addition, sensory stimulation of the ocular surface leading to tearing was demonstrated to be connected to blinking and interblink intervals.[13] It was discussed in DEWS II that the quality of life among VDT users would probably be improved by behavioral change toward enhancing the blinking rate.[14] In addition, direct anatomical association between the salivary and lacrimal glands was shown in the literature.[15] A few studies also revealed that salivation and mastication induced the tear production.[16,17] Moreover, salivatory improvement was demonstrated to be with an improvement in dry eyes of the patients with Sjögren's Syndrome.[15] Considering the current literature, we hypothesized that chewing might play a role both in lacrimation and blinking rate. Therefore, in this study, we aimed to investigate the role of chewing gum on tear meniscus parameters and blinking rate with objective and quantitative methods.

Materials and Methods

This study was performed in line with ethical principles of the Declaration of Helsinki, and Ethical Committee approved the study. A written informed consent form was obtained from all participants. Sixty eyes of 30 healthy volunteers aged 25–47 years were included in the study. The subjects with acute or chronic ocular, dental, and other systemic diseases, the cases using acute or chronic medication, the individuals having previous history of ocular, dental, maxillofacial trauma and/or surgery, the subjects with any disorder preventing the chewing, and the cases with cooperation deficiency for the examinations were not included in the study. All individuals underwent full ophthalmic examination. We provided a detailed orientation for what the subjects would undergo during the study. Subjects were told that they would chew a gum spontaneously for 30 min and we would take the tear meniscus measurements both before and during chewing gum, 3 times in total. A sugar-free gum was used in the study. Subjects were also told that they would be recorded with the camera of a smartphone for 5 min before and during chewing gum. However, cases initially did not know that this recording was taken for blinking observation. At the end of the study, the actual reason for the registration was explained. The reason why the volunteers were recorded in a masked fashion was because we suggested that knowing they were being recorded for the purpose of blinking observation would affect their behavior.

Tear meniscus parameters were measured using spectral domain anterior segment optical coherence tomography (AS-OCT) device (Cirrus HD-OCT 4000, software version 6.5.0; Carl Zeiss Meditec, Inc. Dublin, CA, USA). Same investigator performed all measurements under mesopic room illumination with a constant temperature and humidity. Measurements were taken bilaterally and inferior tear meniscus was captured. The average value of three measurements from each eye was taken for all analyses. Before the measurements, subjects were instructed to blink 3 times and then not to blink for five seconds. Following the blinking, we acquired an image of tear meniscus at the border of inferior central cornea-eyelid junction. Three tear meniscus OCT measurements were included in the study. The first measurement was the image which was taken before chewing gum. The second measurement was the image which was obtained at 15 min of chewing gum, and the third measurement was acquired at 30 min of chewing gum. Mean blinking rate was defined as total blinking count/5 minutes. The first five-minute recording for the blinking rate was taken before chewing gum. The second 5-min recording was obtained during chewing gum between 20 and 25 min. Acquired images were extracted to ImageJ sotware (Pubmed, version 1.53). We used the Image J software to calculate the tear meniscus height (TMH), tear meniscus depth (TMD), and tear meniscus area (TMA). TMH was defined as the distance from cornea-tear film junction at the superior to lower eyelid-tear film junction at the inferior. TMD was defined as the distance from cornea-lower eyelid junction to the midpoint of the tear film. The borders of the tear meniscus were determined with a caliper, and the area within the lines was measured as TMA.

We used the Statistical Package for the Social Sciences version 20.0 software for Windows (IBM Corporation, Armonk, NY) to analyze the variables in this study. Descriptive characteristics were given as mean±standard deviation values. Count data were presented as case number (percentage). Shapiro–Wilk test was performed to

assess the normality of the data. Friedman test followed by Wilcoxon post hoc test was used to compare tear meniscus parameters of the first, second, and third measurements. Wilcoxon test was performed to compare blinking rates before and during chewing gum. P<0.05 was considered statistically significant.

Results

Mean age of the individuals was 30±6 years. Fifteen (50%) of the cases were male and fifteen (50%) were female. TMH, TMD, and TMA values at fifteen (342±43 μm, 256±63 μm, 37.8±15.3 μm^2, respectively) and 30 (339±54 μm, 247±58 μm, 33.6±13.3 μm^2, respectively) min of chewing gum were significantly higher than those values (224±32 μm, 190±45 μm, 25.6±12.2 μm^2, respectively) before chewing gum (p<0.001). On the other hand, TMH, TMD, and TMA values at 15 min of chewing gum were similar to those values at 30 min of chewing gum (p>0.05). Tear meniscus parameters before and at 15 and 30 min of chewing gum were exhibited in Table 1. Mean blinking rate was 17±5/min before chewing gum, and 42±14/min during chewing gum. Blinking rate during chewing gum was significantly higher than that value before chewing gum (p<0.001).

Discussion

Anatomical and functional association between the salivation and lacrimation was demonstrated in prior studies.[16-18] It is very well-known that the facial nerve contains fibers both for submandibular salivary gland and lacrimal gland.[18] One study also revealed that patients with dry eye exposed the improvement in complaints of dry eye following the treatment for salivary hypofunction.[15] A recent study investigating the effect of chewing on tear production in 12 healthy subjects reported that Schirmer test showed significant improvement.[17] In addition, a prior study stated that a candy with a sour taste leaded in salivation and lacrimation, and the authors demonstrated the increasing lacrimation with Schirmer test.[16] However, Schirmer test has its own challenges which have been widely discussed in the literature.[19,20] The major limitations of the Schirmer test are being an invasive test and being depended on the experience of the performer and need for co-operation of the patient, particularly pediatric population is not a preferable candidate for this test. There is no definite consensus on whether the eyes should be open or closed and whether the topical anesthesia should be applied or not.[19] As shown in the literature, low repeatability seems to be one of the concerns about the test.[20] Therefore, in this study, we aimed to investigate the role of chewing gum on tear production with non-invasive, more quantitative, good repeatable, and more reliable method, and this was why we measured the tear meniscus with AS-OCT. In the literature, AS-OCT was shown to be non-invasive, reliable, and repeatable method to measure and monitor the tear meniscus parameters.[21-25] Reflex tearing during Schirmer test can be seen, and it was demonstrated that OCT did not cause reflex tearing, thus providing more accurate tear fluid evaluation.[24,25] In previous studies, it was found that tear meniscus parameters determined by OCT were significantly lower in cases with dry eye compared to healthy individuals.[24,26] In the present study, significant differences in all three tear meniscus parameters were detected between the measurements before and during chewing gum. According to our measurements, we can suggest that tear production increases in the 15 min and continues until the 30 min. However, it is not clear how long the increases in tear meniscus parameters will last because we ceased the chewing gum at the 30 min and no further measurements were acquired after the 30 min.

Since blinking action clears the debris and re-forms the tear film, it is vital in maintaining healthy ocular surface and optical performance.[27,28] The blinking motion ensures that the tear film is evenly distributed on the ocular surface.[28] In addition, the pressure created by the orbicularis oculi and Riolan's muscles during blinking motion was believed to stimulate meibomian glands to secrete the lipid layer preventing tear evaporation.[29] Normally, the average blinking rate was stated in a range between 10 and 22/min in the literature.[30] Low blinking rate was reported to be associated with DED.[31] Reduced number of blinking can cause increased tear evaporation from the

Table 1. Tear meniscus parameters before and at 15 and 30 min of chewing gum

Parameters	Before chewing gum (1)	15 min of chewing gum (2)	30 min of chewing gum (3)	p1-2	p1-3	p2-3
TMH	224±32	342±43	339±54	<0.001	<0.001	0.82
TMD	190±45	256±63	247±58	<0.001	<0.001	0.79
TMA	25.6±12.2	37.8±15.3	33.6±13.3	<0.001	<0.001	0.37

Descriptive characteristics were given as mean±standard deviation values. TMH: Tear meniscus height (μm); TMD: Tear meniscus depth (μm); TMA: Tear meniscus area (μm^2); Friedman test, followed by Wilcoxon post hoc test was used. P<0.05 statistically significant.

ocular surface, ocular discomfort, and dry eye complaints.[27,28] In literature, the stimulated increase in blinking rate was reported to improve dry eye symptoms.[29,31] When we evaluated the blinking rate before and during chewing gum in our study, we observed a significant increase in blinking rate during chewing gum. Despite the literature supporting that chewing itself could increase the tear production,[17] we noticed that previous study did not mention the increased blinking rate. According to our outcomes, we thought that chewing gum increased both tear production and blinking rate at acute phase of chewing.

In this study, there were some limitations such as the lack of a control group and the small participant group. The other limitation of the study was that it was conducted on healthy individuals and that it was not studied especially in cases of dry eye due to aqueous type insufficiency. Another limitation was the observation of the chewing effects during a relatively short-term period. In addition, regarding the standardization of the chewing gum, a few questions might also arise about whether a chewing scale from soft to hard could have any impact on the outcomes. Therefore, future studies may investigate the effects of chewing gum on tear production in terms of duration, and softer or harder chewing. In addition, since the study was performed in healthy subjects, the outcome of the study should be investigated with randomized-control studies in cases of dry eye due to aqueous type insufficiency.

Considering the benefits of chewing gum, it is cheap, sustainable, easy to reach, non-invasive, and not requiring drug-receptor interactions. Since it is not a drug, we can suggest that there is no minimum effective concentration to begin the effect of chewing. We can also assume that there is no risk of drug-related events such as side effects, and toxication might not be anticipated.

Conclusion

To the best of our knowledge, this was the first study demonstrating that chewing gum increased tear meniscus parameters and blinking rate at acute phase of chewing with objective, quantitative, and non-invasive methods. According to our outcomes, we thought that chewing gum might improve dry eye-related complaints by increasing the tear production and blinking rate.

Ethics Committee Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This study was performed with approval of our hospital medical research ethical committee (approval number: 2023/5-3) and in line with ethical principles of the Declaration of Helsinki.

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: H.O., H.A., E.A.; Design: H.O., H.A., E.A.; Supervision: H.O., H.A.; Resource: H.O., E.A.; Materials: H.O., H.A., E.A.; Data Collection and/or Processing: H.O., H.A.; Analysis and/or Interpretation: H.O., E.A.; Literature Search: H.O., H.A.; Writing: H.O., H.A.; Critical Reviews: H.O., E.A.

Conflict of Interest: None declared.

Use of AI for Writing Assistance: Not declared.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Craig JP, Nichols KK, Akpek EK, Caffery B, Dua HS, Joo CK, et al. TFOS DEWS II definition and classification report. Ocul Surf 2017;15:276–83. [CrossRef]
2. Stapleton F, Alves M, Bunya VY, Jalbert I, Lekhanont K, Malet F, et al. TFOS DEWS II epidemiology report. Ocul Surf 2017;15:334–65. [CrossRef]
3. Farrand KF, Fridman M, Stillman IÖ, Schaumberg DA. Prevalence of diagnosed dry eye disease in the United States among adults aged 18 years and older. Am J Ophthalmol 2017;182:90–8. [CrossRef]
4. Öztürk H, Özen B. The effects of smartphone, tablet and computer overuse on children's eyes during the COVID-19 pandemic. J Pediatr Res 2021;8:491–7. [CrossRef]
5. Blehm C, Vishnu S, Khattak A, Mitra S, Yee RW. Computer vision syndrome: A review. Surv Ophthalmol 2005;50:253–62. [CrossRef]
6. Yokoi N, Uchino M, Uchino Y, Dogru M, Kawashima M, Komuro A, et al. Importance of tear film instability in dry eye disease in office workers using visual display terminals: The Osaka study. Am J Ophthalmol 2015;159:748–54. [CrossRef]
7. Rahman EZ, Lam PK, Chu CK, Moore Q, Pflugfelder SC. Corneal sensitivity in tear dysfunction and its correlation with clinical parameters and blink rate. Am J Ophthalmol 2015;160:858–66. e5. [CrossRef]
8. Jones L, Downie LE, Korb D, Benitez-Del-Castillo JM, Dana R, Deng SX, et al. TFOS DEWS II management and therapy report. Ocul Surf 2017;15:575–628. [CrossRef]
9. Willcox MD, Argüeso P, Georgiev GA, Holopainen JM, Laurie GW, Millar TJ, et al. TFOS DEWS II tear film report. Ocul Surf 2017;15:366–403. [CrossRef]
10. Brinton M, Chung JL, Kossler A, Kook KH, Loudin J, Franke M, et al. Electronic enhancement of tear secretion. J Neural Eng 2016;13:016006. [CrossRef]
11. Kossler AL, Wang J, Feuer W, Tse DT. Neurostimulation of the lacrimal nerve for enhanced tear production. Ophthalmic Plast Reconstr Surg 2015;31:145–51. [CrossRef]
12. Dieckmann G, Fregni F, Hamrah P. Neurostimulation in dry eye disease-past, present, and future. Ocul Surf 2019;17:20–7.

13. Wu Z, Begley CG, Port N, Bradley A, Braun R, King-Smith E. The effects of ıncreasing ocular surface stimulation on blinking and tear secretion. Invest Ophthalmol Vis Sci 2015;56:4211–20.
14. Wolffsohn JS, Arita R, Chalmers R, Djalilian A, Dogru M, Dumbleton K, et al. TFOS DEWS II diagnostic methodology report. Ocul Surf 2017;15:539–74. [CrossRef]
15. Lai Z, Yin H, Cabrera-Pérez J, Guimaro MC, Afione S, Michael DG, et al. Aquaporin gene therapy corrects Sjögren's syndrome phenotype in mice. Proc Natl Acad Sci U S A 2016;113:5694–9.
16. Pramanik T, Ghising R. Salivation induced better lacrimal gland function in dry eyes. Nepal Med Coll J 2009;11:258–60.
17. Asakawa K, Ooka H, Honda M, Yanagiuchi K, Yoshimura K, Ishikawa H. Effects of chewing gum for tear production in healthy young subjects. Acta Ophthalmol 2021;99:e1539–40.
18. Dartt DA. Neural regulation of lacrimal gland secretory processes: Relevance in dry eye diseases. Prog Retin Eye Res 2009;28:155–77. [CrossRef]
19. Savini G, Prabhawasat P, Kojima T, Grueterich M, Espana E, Goto E. The challenge of dry eye diagnosis. Clin Ophthalmol 2008;2:31–55. [CrossRef]
20. Nichols KK, Mitchell GL, Zadnik K. The repeatability of clinical measurements of dry eye. Cornea 2004;23:272–85. [CrossRef]
21. Arriola-Villalobos P, Fernández-Vigo JI, Díaz-Valle D, Peraza-Nieves JE, Fernández-Pérez C, Benítez-Del-Castillo JM. Assessment of lower tear meniscus measurements obtained with Keratograph and agreement with Fourier-domain optical-coherence tomography. Br J Ophthalmol 2015;99:1120–5. [CrossRef]
22. Wei A, Le Q, Hong J, Wang W, Wang F, Xu J. Assessment of lower tear meniscus. Optom Vis Sci 2016;93:1420–5. [CrossRef]
23. Karadenız Ugurlu S, Altın Ekın M, Aytogan H. Assessment of tear meniscus by optical coherence tomography in patients with canalicular laceration repair. Int Ophthalmol 2020;40:13–8.
24. Akiyama R, Usui T, Yamagami S. Diagnosis of dry eye by tear meniscus measurements using anterior segment swept source optical coherence tomography. Cornea 2015;34 Suppl 11:S115–20. [CrossRef]
25. Fukuda R, Usui T, Miyai T, Yamagami S, Amano S. Tear meniscus evaluation by anterior segment swept-source optical coherence tomography. Am J Ophthalmol 2013;155:620–4, 624.e1–2.
26. Ibrahim OM, Dogru M, Takano Y, Satake Y, Wakamatsu TH, Fukagawa K, et al. Application of visante optical coherence tomography tear meniscus height measurement in the diagnosis of dry eye disease. Ophthalmology 2010;117:1923–9. [CrossRef]
27. Freudenthaler N, Neuf H, Kadner G, Schlote T. Characteristics of spontaneous eyeblink activity during video display terminal use in healthy volunteers. Graefes Arch Clin Exp Ophthalmol 2003;241:914–20. [CrossRef]
28. Jaiswal S, Asper L, Long J, Lee A, Harrison K, Golebiowski B. Ocular and visual discomfort associated with smartphones, tablets and computers: What we do and do not know. Clin Exp Optom 2019;102:463–77. [CrossRef]
29. Kim AD, Muntz A, Lee J, Wang MT, Craig JP. Therapeutic benefits of blinking exercises in dry eye disease. Cont Lens Anterior Eye 2021;44:101329. [CrossRef]
30. Rodriguez JD, Lane KJ, Ousler GW 3rd, Angjeli E, Smith LM, Abelson MB. Blink: Characteristics, controls, and relation to dry eyes. Curr Eye Res 2018;43:52–66. [CrossRef]
31. Wang MT, Tien L, Han A, Lee JM, Kim D, Markoulli M, et al. Impact of blinking on ocular surface and tear film parameters. Ocul Surf 2018;16:424–9. [CrossRef]