Original Article

Correlation between dry eye and refractive error in Saudi young adults using noninvasive Keratograph 4

Rania M Fahmy[1,2], Amal Aldarwesh[1]

Purpose: The purpose is to study the correlation between dry eye and refractive errors in young adults using noninvasive Keratograph. **Methods:** In this cross sectional study, a total of 126 participants in the age range of 19–25 years and who were free of ocular surface disease, were recruited from King Saud University Campus. Refraction was defined by the spherical equivalent (SE) as the following: 49 emmetropic eyes (±0.50 SE), 48 myopic eyes (≤–0.75 SE and above), and 31 hyperopic eyes (>+0.75 SE). All participants underwent full ophthalmic examinations assessing their refractive status and dryness level including noninvasive breakup time (NIBUT) and tear meniscus height using Keratograph 4. **Results:** The prevalence of dry eye was 24.6%, 36.5%, and 17.4% in emmetropes, myopes, and hypermetropes, respectively. NIBUT has a negative correlation with hyperopia and a positive correlation with myopia with a significant reduction in the average NIBUT in myopes and hypermetropes in comparison to emmetropes. **Conclusion:** The current results succeeded to demonstrate a correlation between refractive errors and dryness level.

Key words: Dry eye, Keratograph 4, refractive error, tear film breakup time, tear meniscus height

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Dry eye syndrome (DES) is a common disorder that eye care providers encounter on a daily basis in which it accounts for 25% of patients' visits.[1] The report of the epidemiology subcommittee of the 2007 International Dry Eye Workshop (DEWS) revealed that the prevalence of dry eye lies somewhere in the range of 5%–30% in the population aged 50 years and older.[2] Studies have found that DES affects more women than men, especially after menopause.[3-6]

It is characterized by discomfort symptoms such as burning, tearing, foreign body sensation, and ocular fatigue. Moreover, chronic dry eye is associated with inflammatory ocular surface and damage. The change in tear film osmolarity is also another outcome of DES as stated in 2007 definition of DES by DEWS. Recently, the Tear Film and Ocular Surface Society DEWS II has revised the definition as follows:

"Dry eye is a multifactorial disease of the ocular surface characterized by a loss of homeostasis of the tear film, and accompanied by ocular symptoms, in which tear film instability and hyperosmolarity, ocular surface inflammation and damage, and neurosensory abnormalities play etiological roles."[7]

Several risk factors have been reported to increase the risk of DES such as the is the long-term wear of contact lens and refractive surgery such as laser-assisted *in situ* keratomileusis or photorefractive keratectomy (LASIK).[8,9] Questionnaire-based studies have shown that contact lens wearers have symptomatic DES than noncontact lens wearer.[10-12] Data obtained from self-reported questionnaires lack the connection between the rate and severity of DES and the status of the clinical refractive status. On the other hand, a common finding between these studies is that approximately 50% of contact lens wearer reported dry eye.[10-14] Interestingly, spectacle lens and contact lens wearers were twice and 12 times, respectively, more likely than emmetropes to report DES.[15] Symptomatic dry eye could be diagnosed in the clinic through examining the tear film stability. This could be achieved through measuring the tear breakup time using newly developed apparatus such as the Keratograph. Diagnostic tests of DES such as tear breakup time, Schirmer's test, corneal fluorescein staining, the rose bengal staining, and tear lysozyme and lactoferrin test are all traditional methods that have pros and cons. Hence, the noninvasive diagnostic test is always preferred by both the clinicians and the patients; the Keratograph is a promising noninvasive method that has several advantages over other methods. For instance, Keratograph 4 has been reported to identify significantly lower NIBUT values than the Tearscope.[16] A recent article by Abdelfattah *et al*.[17] demonstrated the advantage of using Keratograph compared to a traditional fluorescein-based method in measuring the tear film dynamics. Studies have also shown that Keratograph gives more consistent results over traditional methods using fluorescein staining.[18,19] One study by Srinivasan *et al*.[20] found that Keratograph 4 is useful clinically to image the meibomian gland structure and detect changes in symptomatic dry eye

[1]Department of Optometry and Vision Sciences, King Saud University, Riyadh, Saudi Arabia, [2]Department of Ophthalmology, Faculty of Medicine, Cairo University, Giza, Egypt

Correspondence to: Prof. Rania Fahmy, Department of Optometry and Visual Sciences, King Saud University, P.O. Box 89885, Riyadh 11692, Saudi Arabia. E-mail: rfahmy@ksu.edu.sa

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participants. This is in agreement with Abdelfattah *et al*.,[17] who used Keratograph 5 to determine tear meniscus height (TMH) and noninvasive breakup time (NIBUT) values as well as the glandular density and glandular atrophy in DES and Sjögren syndrome. This study aims to add new information about the asymptomatic DES in young adult females by examining the correlation between refractive errors and objective measurements of NITBUT using Keratograph 4.

Methods

The study was approved by the Ethical Committee at College of Applied Medical Sciences, King Saud University, and informed consent followed the tenets of the Declaration of Helsinki.

Participants with best-corrected visual acuity of 6/9 were eligible for this study. The exclusion criteria included those participants with ocular allergic disease, keratitis, ocular surface disease, contact lens wear, glaucoma, previous ocular surgery or injury, or systemic or ocular treatment. In this cross sectional study, a total of 126 participants in the age range of 19–25 years and who were free of ocular surface disease, were recruited from King Saud University Campus. Refraction was defined by the spherical equivalent (SE) as the following: 49 emmetropic eyes (±0.50 SE), 48 myopic eyes (≤–0.75 SE and above), and 31 hyperopic eyes (>+0.75 SE).

All participants underwent full ophthalmic examinations starting with the NIBUT and TMH using Keratograph 4, to avoid the disturbance of tear film stability. This was followed by measurement of refractive error using auto refractometer, visual acuity by Snellen chart, slit-lamp examination, Goldmann applanation tonometry, and the biomicroscopic funduscopy (90D lens).

Keratograph 4 evaluation

All participants underwent imaging with Keratograph 4 (Oculus GmbH, Wetzlar, Germany), a noncontact device that combines keratometric and topographic measuring methods in a single unit. The principle of noninvasive Keratograph 4 tear breakup time (NIKBUT) measurement has been described previously.[19,20] In summary, a single examiner measured the TBUT three times at 5-minute interval using the Oculus NIKBUT tool. The measurement of the corneal surface was carried out through a system of rings which are reflected at the cornea with more than 1000 measurement points per ring, resulting in thousands of analyzed data points per frame. A video recording of the ocular surface begins with real-time detection and localization of breaks in the tear film. The video recording lasts up to a maximum of 25 s or until the patient's next blink. The average NIKBUT is the parameter of interest in the current study. Participants with breakup time ≤10 s were considered to have dryness. In general, TBUT >10 s is thought to be normal, 5–10 s indicates mild-to-moderate dryness, and <5 s is considered severe dryness.[22-24] This cutoff point was also chosen based on the reported agreement between the traditional fluorescein-tear breakup time (FTBUT) and NIBUT.[17,25] Patients were also assessed using a dryness grade 0–2 generated by the Keratograph in which Grade 0 indicates normal finding, Grade 1 reflects mild-to-moderate dryness, and Grade 2 indicates severe dryness. The same examiner carried out the TMH measurements using Oculus Keratograph 4 according to the method described by Santodomingo-Rubido *et al*.;[26] TMH is divided into three grades from Grade 0 to Grade 2 indicating the normal value (>0.2 mm), the critical value (~0.2 mm), and the dry eye (<0.2 mm).

Statistical analysis

All statistical analysis was performed utilizing GraphPad Prism Software v. 7. For Mac, (GraphPad Software, La Jolla California USA, www.graphpad.com). The test was considered significant when $P \leq 0.5$. Analysis of variance was used to compare NIBUT and TMH between the groups. Linear regression was used to investigate the association between NIBUT, TMH, and refractive errors.

Results

Tear meniscus height and noninvasive Keratograph 4 tear breakup time

The Oculus Keratograph 4 recorded no statistical difference in automated TMH values between the studied groups [Fig. 1a and b]. On the other hand, the tear breakup time in seconds as measured by Keratograph 4 (NIKBUT) showed significant shorter time in eyes of myopic and hyperopic individuals compared to emmetropia [9.7: 9.4: 12.2 s, respectively, $P \leq 0.5$; Fig. 2a and b]. The correlation between refractive errors, TMH, and NIKBUT is displayed in Table 1. A weak positive relationship was found between NIKBUT and myopia ($r = 0.295$) while a significant inverse relationship was found between NIKBUT and hyperopes ($r = -0.405$). Based on the NIKBUT values, the participants were categorized into having no dryness ($n = 27$), mild-to-moderate dryness ($n = 80$), or severe dryness ($n = 19$) in relation to their refractive errors as shown in Fig. 3. Among the participants in this study, no myopes were found to be free of dryness while they constitute the majority in mild-to-moderate dryness class (51.3%, $n = 41$). Individuals with hyperopia were the majority of the severe dryness class (63.2%, $n = 12$).

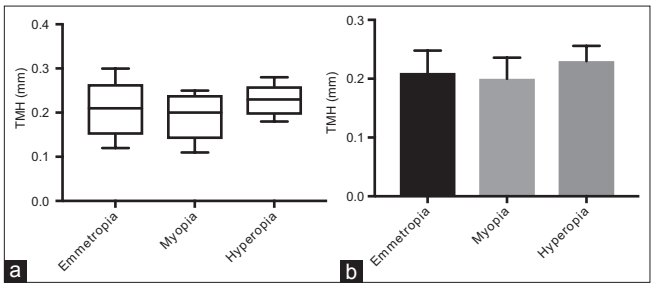

Figure 1: (a) Box-and-whisker plot showing the tear meniscus height and its average values (b) in participants with different refractive error status

Table 1: Correlation of clinical examination results of dry eye and refractive error (Spearman)

	Emmetropia	Myopia	Hyperopia	TMH
NIBUT	−0.104	0.295*	−0.405*	−0.002
TMH	0.003	−0.006	0.251	-
n	49	46	36	

NIBUT: Noninvasive breakup time, TMH: Tear meniscus height, *Significant at $P \leq 0.5$

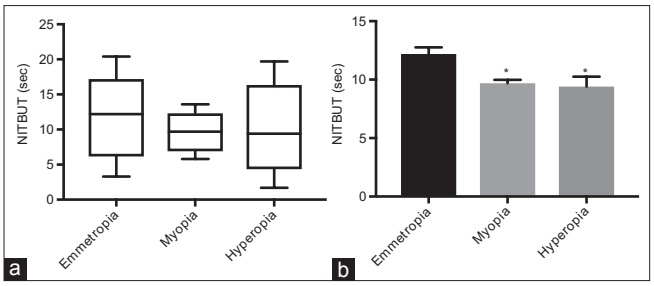

Figure 2: (a) Box-and-whisker plot showing the noninvasive tear breakup time and (b) its average values in participants with different refractive error status. *$P \leq 0.05$

Discussion

DES is a common disorder that affects a significant percentage of the populations worldwide. The influence of female sex hormones on the tear film stability makes females more vulnerable to DES and reports more symptoms than males.[4] Studies have shown that postmenopausal women are more affected by DES due to lack of hormonal support.[21-23] This limits the focus of dry eye research to individuals over the age of 50 years in both genders.[3,5,27] The rate of dry eye in young adults is not well known although the visual tasks that younger adults are taking nowadays make them more vulnerable to DES. Video games, computers, and different digital devices as well as contact lenses are all contributing to the development of DES in younger patients.[28-31] Studies have revealed that the overuse of smartphones is associated with increased risk of DES in children.[32-34] Moreover, very few studies have shown evidence that refractive errors could contribute to the development of DES in young individuals.[35,36] The aim of this study was to examine the prevalence of DES among young Saudi females in relation to the refraction error. Relying on NIBUT and TMH, the current study shows that both myopic and hyperopic individuals have significantly reduced NIBUT values of <10 s which is indicative of dryness in 61% of the participants although the TMH values were in normal range. This is in agreement with findings from Wang *et al*.,[36] who reported high prevalence of DES among myopic teenagers using Keratograph 5M. In another study, Lin *et al*.[27] found a correlation between the breakup time and meibomian gland disease. Interestingly, undercorrection of refractive error and female gender was found to significantly associate with dry eye symptoms despite a near normal tear film breakup time.[37] This supports the notion that refractive error could be linked to DES as found in the current study. Unfortunately, the mechanism of refractive error inducing eye dryness is unknown. The cross-sectional design of this study allowed screening of dryness among people with refractive error, but it would have been interesting to find the relation in terms of causality. As stated earlier, individuals with refractive error are among those with a higher rate of contact lens and spectacle use as well as the reported rate of dryness.[15] Clinically, the changes in the anterior corneal surface as the eyeball elongates in myopia may contribute to increase the likelihood of developing dryness.[35,37-39] In conclusion, noninvasive ocular surface examinations using Keratograph 4 showed a low NIBUT in healthy participants with refractive error which could be indicative of DES. Although it would have been interesting to examine the relationship between the refractive error and development of DES, the present data need to be supported by a further study of larger population.

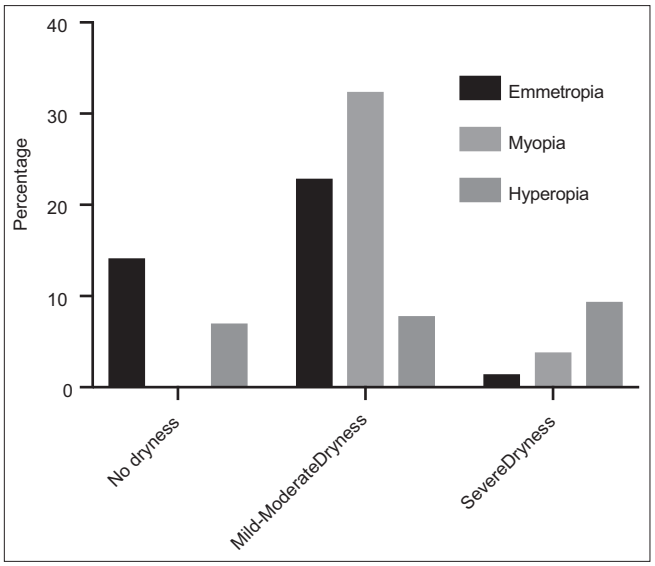

Figure 3: Percentage of dryness in relation to refractive status ($n = 126$)

Conclusion

Results succeeded to demonstrate a correlation between refractive errors and dryness level.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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