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Retrospective Study

Impact of COVID-19 pandemic on the ocular surface

Marta A *et al*. COVID-19 and ocular surface

Abstract

BACKGROUND

There have been increased reports of dry eyes in the coronavirus disease 2019 (COVID-19) pandemic era.

AIM

To analyze the differences in tear film properties pre and post COVID-19 pandemic era.

METHODS

It was a retrospective comparative study. Patients were divided into 3 groups according to the date of multimodal ocular surface evaluation: Group 1 if it was before Portugal lockdown decision (from August 2019 to March 2020), group 2 if it was after Portugal lockdown decision but without mask mandate (from April 2020 to October 2020) and group 3 if it was after Portugal lockdown but with mask mandate in health public highway (from November 2020 to April 2021). The following variables were analyzed: Lipid layer thickness (LLT), blink rate (BR), Schirmer test (ST), tear meniscus height (TMH), tear osmolarity (OSM), non-invasive break-up time (NIBUT), and loss area of the meibomian glands (LAMG).

RESULTS

The study included 548 eyes of 274 patients, aged 18 to 89 years, with a mean age of 66.15 ± 13.40 years at the time of multimodal ocular surface evaluation. Compared to group 1: Mean LLT was better in group 2 ($P = 0.001$) and group 3 ($P < 0.001$); ST was similar in group 2 ($P = 0.576$) and better in group 3 ($P = 0.002$); OSM and LAMG were worse in group 2 ($P = 0.031$ and $P < 0.001$, respectively) and in group 3 (both with $P < 0.001$); BR and TMH were similar in group 2 ($P = 0.821$ and $P = 0.370$, respectively) and worse in group 3 ($P < 0.001$ and $P = 0.038$, respectively); and NIBUT was worse in group 2 ($P = 0.030$) and similar in group 3 ($P = 0.263$).

CONCLUSION

Our study demonstrated that differences exist in tear film properties comparing pre- and post-pandemic COVID-19 era.

Key Words: Ocular surface; Dry eye; Face masks; Mask-associated dry eye; COVID-19 pandemic

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Core Tip: There were differences in tear film properties comparing pre- and post-pandemic coronavirus disease 2019 era. Over time, there was an increase in the lipid layer thickness, a decrease in the area of the meibomian glands, and a decrease in the blink rate. These changes seemed related to face masks and screen time. Therefore, the ophthalmologist must be aware of these changes and educate patients according to the most likely potential causal factor.

INTRODUCTION

On 11th March 2020, a new global pandemic was declared by the World Health Organization: The severe acute respiratory syndrome caused by the coronavirus 2019-nCOV[1]. The spread was primarily *via* respiratory droplets. With widespread and no vaccine or validated therapies, some public health measures had been adopted to control the pandemic situation[2]. Critical strategies included the use of personal protective equipment such as face masks[3], and also physical distancing and hand hygiene. There was an increase on the demand placed on healthcare workers including ophthalmologists, and many suffered burnout[4]. To avoid social contact, some countries like Portugal declared lockdown, and other measures like mandatory telework and face mask in the public highway and closed spaces. Thereby, screen time increased considerable because most of the work and meetings were performed through

devices[3]. Screen time is a well-known risk factor for dry eye disease[5-7]. The main causative factor is thought to be the increase of evaporation of tear fluid attributable to prolonged time without blinking while gazing. On the other hand, it is known that the prolonged use of face masks, besides pain and pressure on the nose and ears can also lead to increased respiratory resistance, temporomandibular joint changes, and ocular discomfort[8-12]. The voluntary or involuntary displacement of the mask could direct the breathing air around the eyes leading to rapid evaporation of tears[3,6]. Due to increased reports of dry eyes[6,13], term mask-associated dry eye was created by scientists from Canada to describe dry eye after use of face mask[14-16]. According to the authors' knowledge, there is no published study in the literature about the differences in tear film properties comparing pre- and post- coronavirus disease 2019 (COVID-19) pandemic. Our study aimed to evaluate what are the tendencies in this area after the new pandemic reality.

MATERIALS AND METHODS

Study design

A retrospective comparative study including those who underwent multimodal ocular surface evaluation in the Ophthalmology Department of Centro Hospitalar Universitário do Porto, between August 2019 and April 2021. This study was conducted following the tenets of the Declaration of Helsinki (1964). The authors ensured that all patients' anonymity was carefully protected. Study approval was obtained from the "Departamento de Ensino, Formação e Investigação".

Participants

We included all adult patients with complete multimodal ocular surface evaluation in the past (as mentioned in the parameters section). Patients who performed any ocular surgery (excepting cataract surgery if performed more than 6 mo before ocular surface evaluation) or meibomian gland dysfunction treatments with laser devices such as intense pulsed light were excluded. Contact lens wearers were also excluded.

After collection, patients were divided into 3 groups according to the date of multimodal ocular surface evaluation: Group 1 if it was before Portugal lockdown (until March 2020), group 2 if it was after Portugal lockdown decision but without mask mandate (from April to October 2020) and group 3 if it was after Portugal lockdown but with mask mandate in health public highway (from November 2020 to April 2021).

Parameters

The following variables were analyzed: Demographic characteristics and multimodal ocular surface evaluation. The last, as recommended by international consensus[17], included: (1) Tear film stability [tear osmolarity (OSM), non-invasive break-up time (NIBUT)]; (2) Tear volume [Schirmer test (ST), tear meniscus height (TMH)]; (3) Tear film composition [tear OSM, lipid layer thickness (LLT)]; and (4) Eyelid aspects [loss area of the meibomian glands (LAMG) and blink rate (BR) analysis].

ST I was chosen to evaluate tear production or basic secretion. The ST was performed after the instillation of a topical anesthetic. To minimize irritation of the cornea during the test, a thin filter-paper strip (5 mm wide, 30 mm long) was placed at the junction of the middle and lateral thirds of the lower eyelid, with 5 mm of the paper's length folded into the inferior cul-de-sac and the remaining 25 mm projecting over the lower eyelid. The test was performed with the patient's eyes closed to eliminate blinking. We used TearLab® Osmolarity System (Tearlab, San Diego, CA, United States) to evaluate tear OSM. We used IDRA® Ocular Surface Analyser (SBM SISTEMI, Italy) to assess the NIBUT, BR, LLT through auto-interferometry, LAMG through meibography, and TMH. The BR determines the quality of blinking. It measures blink frequency, count of full blinks, of partial blinks, and duration between blinks.

Statistical evaluation of data

Statistical analysis was performed using the SPSS program (SPSS Statistics, version 22.0 for Windows, SPSS Inc., IBM, Somers, NY). We used the Kolmogorov-Smirnov test to evaluate the normality of the variables, the T-Student test to compare - between

independent continuous variables, and the Fisher exact test was used for nominal scaled data. We considered statistically significant, *P* values less than 0.05.

RESULTS

Demographic data

The study included 548 eyes of 274 patients, 43.4% male and 56.6% female, aged 18 to 89 years. The mean age was 66.15 ± 13.40 years at the time of multimodal ocular surface evaluation. In group 1 were included 290 eyes of 145 patients, 44.8% male and 55.2% female, aged 18 to 89 years with a mean age of 65.01 ± 15.05. In group 2 were included 40 eyes of 20 patients, 40% male and 60% female, aged 21 to 87 years with a mean age of 64.15 ± 15.58. In group 3 were included 216 eyes of 108 patients, 42.2% male and 57.8% female, aged 29 to 85 years with a mean age of 68.06 ± 10.01.

Ocular surface evaluation

The mean values and grade frequencies of the quality of tear film parameters according to the three groups are represented in Table 1 and Figures 1 and 2. The mean LLT was better in group 2 ($P = 0.001$) and group 3 ($P < 0.001$), compared to group 1. These differences were also expressed in grade frequencies in figure 2 ($P < 0.001$). The mean Schirmer value was similar in group 2 ($P = 0.576$) and better in group 3 ($P = 0.002$), compared to group 1. These differences were also expressed in grade frequencies in figure 2 ($P = 0.013$).

The mean OSM and LAMG were worse in group 2 ($P = 0.031$ and $P < 0.001$, respectively) and in group 3 (both with $P < 0.001$), compared to group 1. Although these differences were also expressed in grade frequencies for OSM ($P < 0.001$), it wasn´t enough to change the grade frequencies for the LAMG ($P = 0.529$). The mean BR and TMH were similar in group 2 ($P = 0.821$ and $P = 0.370$, respectively) and worse in group 3 ($P < 0.001$ and $P = 0.038$, respectively), compared to group 1. These differences were also expressed in grade frequencies for BR ($P < 0.001$), but it wasn't enough to change the grade frequencies for TMH ($P = 0.598$). The mean NIBUT was worse in group 2 (P =

0.030) and similar in group 3 (P = 0.263), compared to group 1. These differences were also expressed in grade frequencies (P < 0.001). The grade frequencies of quality of tear film parameters according to the months included in the analysis are represented in Figures 3 and 4.

DISCUSSION

The ocular manifestations of severe acute respiratory syndrome coronavirus-2 infection are known not to pose particular treatment problems, being self-limiting and healing spontaneously[18]. The results of our study suggest differences in film properties before and after the COVID-19 era independently of infection, probably related to the different behaviours (screen time, face mask, *etc.*).

After the lockdown period without face mask mandate, the NIBUT significantly decreased, LLT and OSM increased and there was a significantly higher LAMG. In this period, although there was no face mask mandate for public highways in Portugal, people used it frequently since it was needed for public services. The trigger factor initiating the cascade of structural changes of the tear film is probably the air directed at the ocular surface during expiration[6,13]. The hypothesis that high air velocity causes evaporation of water from the precorneal tear film was confirmed by some studies[19,20]. This can explain the decrease of NIBUT, also shown in a recent study[21]. The LLT increase can be an adaptive response to increase NIBUT; an overestimation since there was a significant decrease of tear film water; or as a result of traumatic secretion of the meibomian gland by face mask. Our study showed a higher LAMG which may mean that face masks can have a mechanical effect, leading to the trauma of meibomian glands in the lower eyelid. The increase of OSM can be explained by the higher proportion of lipid layer (solute) compared to the aqueous layer (solvent) or by the increase of inflammatory markers as already been shown with face mask use in another study[21].

After the lockdown period with face mask mandate, the mean LLT, OSM, and LAMG were kept higher than before the lockdown group. This is supported by the longer

usage time of face masks that occurred consequently to the mandate. However, the mean NIBUT improved. This can be caused by the higher lipid layer together with Shirmer value in this group of patients. The worsened BR could be a long-term consequence of screen time, due to prolonged blinking intervals while gazing[6].

Considering all this, the ophthalmologist must be aware of these changes and educate patients according to the greatest potential causal factor. We recommend an appropriate fitting of the face mask and if necessary with taping top edge on the nose; the frequent use of lubricant eye drops; a limited stay in air-conditioned rooms; and following the 20:20:20 rule regularly to provide breaks from digital devices. Even if face masks are no longer mandatory in this context, we can use this evidence for other professional situations where screen time is prolonged (*e.g.*, administrative) or a face mask is in the routine (*e.g.*, surgeons and nurses in the operating room).

To our knowledge, this is the first study documenting the differences in tear film properties between the pre- and post-pandemic COVID19 era in a real-world study. Two of the strengths of this study are the sample size, including broad age groups, and the multimodal assessment, allowing us to understand better which factors contribute to the loss of the tear film homeostasis. Although it is not a prospective study, we have had an ocular surface evaluation protocol in our department since August 2019, which allowed us to have patients with a complete multimodal assessment of the ocular surface. IDRA® assessment was performed by only 3 technicians (Almeida D, José D, and Sousa P), since August 2019, when the department received the device, therefore we did not consider operator dependent variability as an important factor. The major limitation of this study is not including the evaluation of patient-reported symptoms. Different scales were used along the period analyzed, and comparison is not possible. Additionally, this study has not a control group with patients not using face masks or not exposed to screen time, because it was against recommendations. Prospective studies with a longer follow-up including a time of face mask discontinuation may reveal the possibility of recovery from these changes at the suspension of face masks use and how long will the ocular surface be able to recover the baseline state.

CONCLUSION

Overall, our study demonstrated that differences exist in tear film properties comparing pre- and post-pandemic COVID19 era. Over time, there was an increase in the LLT to compensate for the initial decrease of NIBUT (probably due to evaporation of precorneal tear film by the airflow reaching the ocular surface during expiration with face mask), a decrease in the area of the meibomian glands (probably due to the mechanical effect of face mask on meibomian glands in the lower eyelid) and a decrease in the BR (probably a long-term consequence of screen time). Therefore, the ophthalmologist must be aware of these changes and educate patients according to the most likely potential causal factor.

ARTICLE HIGHLIGHTS

Research background

There have been increased reports of dry eyes in the coronavirus disease 2019 (COVID-19) pandemic era.

Research motivation

Study the ocular surface to better understand the reason for exacerbated dry eye symptoms in the COVID-19 pandemic era.

Research objectives

The purpose was to analyse the differences in tear film properties pre- and post-COVID-19 pandemic era.

Research methods

It was a retrospective comparative study. Patients were divided into 3 groups according to the date of multimodal ocular surface evaluation: Group 1 if it was before Portugal lockdown decision (from August 2019 to March 2020), group 2 if it was after Portugal

lockdown decision but without mask mandate (from April 2020 to October 2020) and group 3 if it was after Portugal lockdown but with mask mandate in health public highway (from November 2020 to April 2021).

Research results

Over time, there was an increase in the lipid layer thickness, a decrease in the area of the meibomian glands, and a decrease in the blink rate. These changes seemed related to face masks and screen time.

Research conclusions

There were differences in tear film properties comparing pre- and post-pandemic COVID-19 era.

Research perspectives

The ophthalmologist must be aware of these changes and educate patients according to the most likely potential causal factor.

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