Tear film dynamics with eyelid and contact lens motion for full blinks and half blinks

DARSHAN RAMASUBRAMANIAN
JOSÉ MANUEL LÓPEZ-ALONSO
JOSÉ LUIS HERNÁNDEZ VERDEJO
DAVID MADRID COSTA
Optics and Optometry Faculty, UCM, Spain. darshram@ucm.es

Aim: The tear film is important in eye optics due to its influence on dry eye, contact lens fit, etc. A mathematical model is used to assess the blinking of eyelids by coupling partial differential equations for tear film thickness to contact lens motion. This article aims to study tear film dynamics when using an experimental real motion of the eyelid and the influence of contact lens motion on the eye in real patient situations.

Experimental method: The dynamics of the tear were simulated with a precorneal tear film model with blinking and contact lens motion. The model uses the standard parameters given in [1], changing the values of the meniscus (experimental values) and the thickness of the contact lens. The eye meniscus height can be measured with Optical Coherence Tomography (OCT) for different patients. The motion of the upper lid during blinking was defined as a sinusoidal function as given in [2], where a fraction parameter is used to represent the difference between half blinks and full blinks. The model was developed with MATLAB software and toolboxes [3].

Results: The principal result given by the model is the thickness between the tear film and the contact lens surface (pre-lens with lens) and the total thickness of the tear film without the contact lens (pre-corneal). The difference between the pre-corneal (PCTF) and pre-lens tear film (PLTF) characterizes the dragging of the tear fluid. Figure 1 shows the simulation of the mathematical model of tear film thickness for an eye fully open after the blink (160 ms) for a sinusoidal eyelid and contact lens motion for full blinks (Figure 1 center) and half blinks (Figure 1 down). The thickness of the pre-lens tear film is higher than the pre-corneal tear film in full blinks, except very close to the lower lid. For a half blink, we see that tear film thickness for a pre-lens tear film is lower at the lower lid.

Discussion: The main difference between pre-corneal tear film and pre-lens tear film is how the contact lens moves the tear fluid in the direction of motion

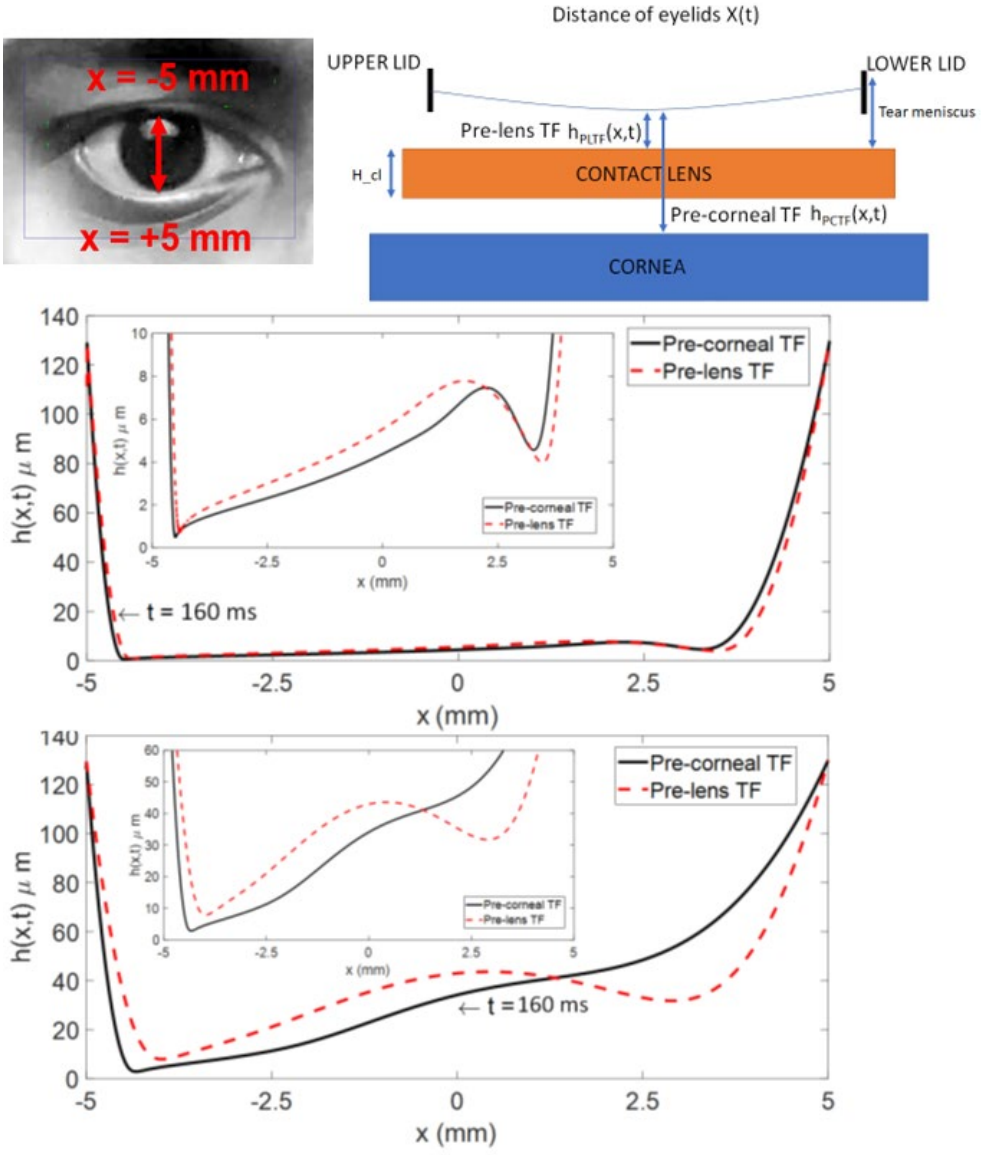

FIGURE 1. Up: Schematic diagram of the precorneal tear film, pre-lens tear film and space coordinates; Center: Tear film thickness at 160 ms after blinking for a full blink; Down: Tear film thickness at 160 ms after blinking for a half blink. Inside center and down images show a zoomed-in version.

and we observe the shift away from the eyelids in the upper lid portion of the tear film thickness, for both full blinks and half blinks. Half blinks improve the

thickness of the pre-lens tear film in the upper portion of the eye while decreasing it in the lower part, compared to full blinks. This could change the stability of the tear film affecting the patient's comfort of wearing the contact lens in situations with a high number of partial blinks (viewing electronic screens such as computers, mobiles, etc.). Moreover, the model permits an assessment of the dynamics of tear films for different patients because tear thickness curves are given as a function of time, which could help in the contact lens fitting process. Tear film dynamics for contact lens wearers could further be explored by modifying certain dynamics, such as complex contact lens motion.

References

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