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21/09/07 OPTOMETRY TODAY

In the blink of an eye

By Karen French and Jane Veys

About the authors

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Did you know that in a lifetime we will spend the same amount of time blinking as we do eating? We spend about five years with our eyes shut because we are blinking. The average person blinks 15 to 20 times a minute, which amounts to more than six million blinks a year.

So why do we blink?

Blinking is a rapid closure movement of the eyelids lasting 300-400ms. Reflex blinking occurs in response to external stimuli and protects the eye from foreign particles, bright light and from injury. Spontaneous blinking is the regular blinking that occurs with no apparent external stimulus. Its main purpose is to moisturise the eye by forming the tear film, to wipe debris from the surface of the eye and to aid tear drainage.

Blinking and the tear film

The eyelids are essential for the distribution and drainage of tears. Blinking helps to spread lacrimal fluid down and across the eyeball. The downward action of the upper lid wipes away debris from the anterior surface of the eye into the lower tear meniscus. The retraction of the upper lid then pulls tear fluid from the lower tear meniscus up over the anterior surface of the eye, restoring the pre-ocular tear film[1]. The goblet cells within the tarsal conjunctiva produce mucus which is spread over the corneal epithelium during a blink to form the deepest layer of the tear film. Efficient blinking maximises the spread and distribution of the mucin over the cornea. Bringing the lids together during blinking promotes secretion of lipids from the meibomian glands[2]. The inner edge of the lid margin then spreads these lipids over the tear film with each blink. This mechanism is illustrated in Figure 1.

Blinking is also important in tear drainage, which is an active process

mediated by the contraction of the orbicularis oculi muscle[3]. Tears collect at the medial canthal angle assisted by the medial movement of the lower lid with each blink. They are drawn into the superior and inferior puncta, and then enter the lacrimal sac via the canaliculi. From the lacrimal sac tears drain into the nasolacrimal duct and into the nasal cavity.

Factors affecting blinking

Blink rate is usually fairly constant for any individual but it can be affected by external conditions[4]. In the literature average blink rates are quoted as anywhere from 10 to 20 blinks per minute[5].

Mental activity can have a significant effect on blink rate. Conversation and verbal recall can increase the rate to in excess of 20 blinks per minute. However, certain types of mental activity can reduce blink rate. General reading has been shown to reduce the rate from an average of 15 blinks per minute to approximately 8 blinks per minute[5]. More demanding visual tasks can reduce blink rate even further[6]. Blink rate is also reduced in down gaze[5]. One of the most widely reported factors affecting blink rate is the use of the computer. In normal healthy people there is on average a five – fold decrease in blink rate during screen use[7]. It has been suggested a mechanism exists for inhibiting spontaneous blinking, sustaining the time between blinks until difficult target recognition tasks have been completed[8].

Blinking can be affected by emotional states, increasing with anger, anxiety or excitement and also with tiredness[9]. The relationship between blinking and emotional state is connected to dopamine activity in the brain where increased dopamine activity results in increased blink rate. In fact many researchers in the field of psychology use spontaneous blink rate as a non-invasive correlate of dopamine function[10]. Patients suffering from certain psychoses, such as schizophrenia, have increased blink rates, whilst Parkinson's disease, characterised by low levels of dopamine, results in decreased blink rates[11].

Many authors report the fact that blink rate is affected by ocular surface condition. As one of the functions of blinking is to re-establish a stable tear film, it seems reasonable to assume that thinning and break-up of the tear film may act as a trigger for the next blink. Indeed it has been shown that there is a significant relationship between tear break-up time and blink rate[12]. Provocative environments that may affect the tear film will also increase blink rate, for example air conditioning, central heating, low humidity, cigarette smoke or windy environments. Newborn babies have a very low spontaneous blink rate, which has been associated with a thick, stable lipid layer increasing the stability of the tear film[13]. Topical anaesthesia of the corneal surface reduces blink rate suggesting that corneal sensitivity to tear break-up or other surface change is involved in blink regulation[14].

Blinking and contact lenses

Contrary to popular clinical opinion, much of the literature suggests that a contact lens has little effect on spontaneous blink rate[6,8]. Because the contact lens forms an artificial surface over the cornea, there is a reduced sense of imminent tear break-up on the anterior surface of the lens. As a result blink rate is less affected by tear film stability on the surface of the contact lens than on the surface of the cornea[15].

Blink rate in contact lens wear is mainly affected by comfort levels. Reflex blink rate may increase initially before adaptation, as a result of the increased foreign body sensation experienced by the lid margins. Similarly a poorly fitting lens may also increase reflex blinking. The modulus of a contact

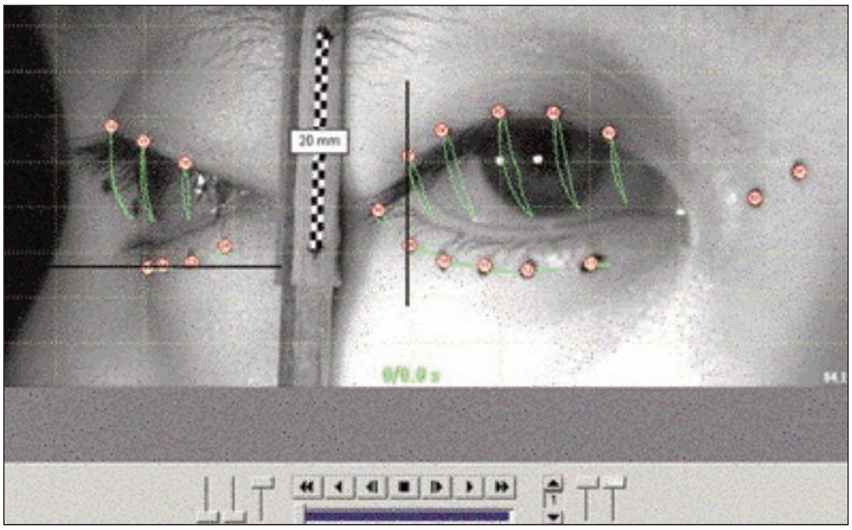

Figure 1: During blinking there is a large downwards movement of the upper lid, with a small medial movement of the lower lid
(courtesy of Johnson and Johnson Vision Care Companies)

lens material relates to its stiffness and hence its mechanical resistance to shape change during blinking. A lens that has a high modulus is less likely to follow the corneal contour during a blink. This may lead to edge fluting and increased awareness of the lens edge on the upper lid margin with each lid movement.

The lubricity of a contact lens material is a measure of how well the material resists friction. In particular the term relates to the level of friction sustained by the eyelid travelling over the lens surface with each blink, particularly if the pre-lens tear film is inadequate. Lenses with a low co-efficient of friction ie higher lubricity, may result in less irritation to the upper lid during blinking and give the lens a smooth feel. Increased friction on the upper lid margin as it moves across a lens surface with poor wettability, in particular a heavily deposited lens, is more likely to increase blink rate[16]. Given that the eye blinks approximately 10,000 times a day or more, the impact of contact lens material and consequent lens comfort is important[17].

A high percentage of contact lens wearers with symptoms of dryness even in the absence of other clinical signs such as corneal staining and reduced tear break-up time have been shown to have lid wiper epitheliopathy (LWE)[18]. The 'lid wiper' is the portion of the marginal conjunctiva of the upper lid that contacts the ocular surface and spreads the tears during blinking (Figure 2). If the tear film provides inadequate lubrication between the lid wiper and the ocular surface there will be increased friction with the ocular surface during blinking. This can result in trauma to the epithelium of the lid wiper and results in a clinically observable change best seen by staining with a combination of fluorescein and rose bengal. When using fluorescein, observation is made easier by instilling two drops five minutes apart. The extent and severity of staining can be graded.

Incomplete blinking

It has been demonstrated that 10-20% of people show incomplete blinking whilst carrying out visual tasks. The rate of incomplete blinking may vary widely between individuals and will also depend on external factors such as ambient conditions, fatigue, mental alertness and difficulty of reading task.

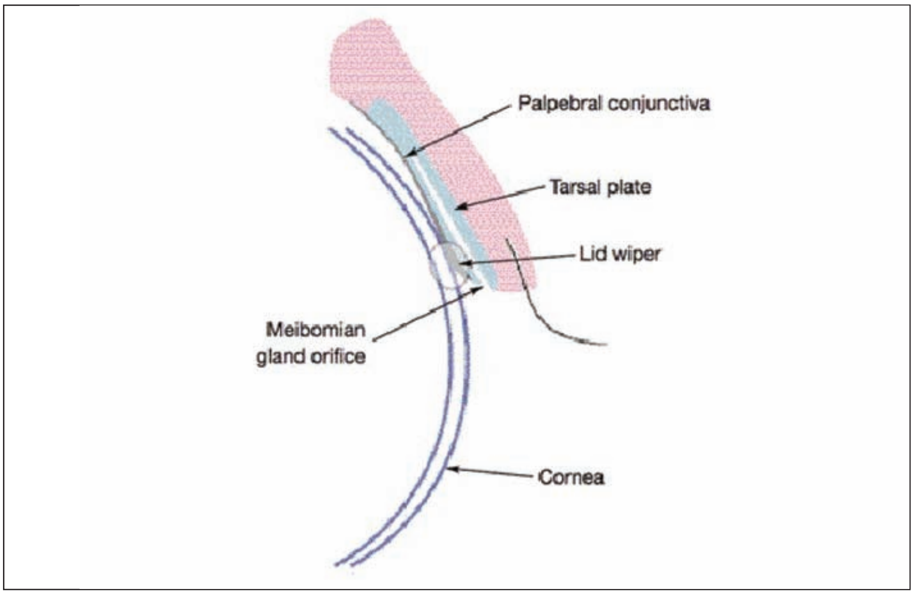

Figure 2a: Schematic representation of the 'lid wiper'

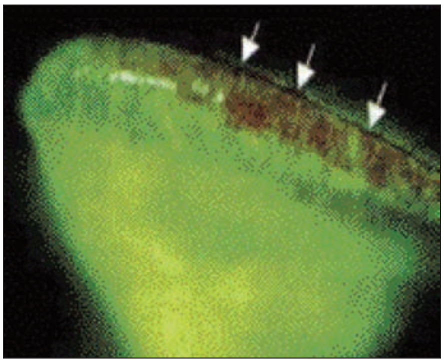

Figure 2b: Staining typically seen in LWE
(courtesy of Don Korb)

McMonnies[16] suggests that incomplete blinking may represent an attempt to inhibit spontaneous blinking whilst concentrating on a visually demanding task. Hence increased rates of incomplete blinking may be directly related to visually or intellectually challenging activity. The consequence of incomplete blinking is a thinner tear film in the inferior cornea, which is more prone to instability. The longer inter-blink periods before re-establishing the tear film in this area leads to greater tear film evaporation and subsequent desiccation of the inferior cornea. Incomplete blinking also decreases the integrity of the mucin and lipid layers within the tears that contributes to the faster tear break-up in the inferior cornea.

McMonnies suggests that the rate of incomplete blinking may increase in patients following laser refractive surgery, possibly as a result of trauma to corneal nerves during photoablation. Contact lens wear can also influence blinking efficiency. Reduced comfort associated with poorly fitting or poorly wetting lenses may cause a decrease in the completeness of blinking.

Factors that may increase blink rate
- Conversation
- Anxiety
- Tiredness
- Provocative environmental conditions (air conditioning, central heating, smoky atmosphere)
- Poor tear film stability

Factors that may decrease blink rate
- Reading
- Increased difficulty of visual task
- Computer use
- Corneal anaesthesia

Table 1: Conditions affecting blink rate

Blinking efficiency exercises

The exposure keratopathy and dryness symptoms that often accompany reduced or incomplete blinking can be managed by encouraging complete and efficient blinking habits. McMonnies[18] proposes blinking efficiency exercises. Patients are instructed to practise 24 complete blinks in a period of no longer than 30 seconds. It is suggested they carry out this exercise every half hour for at least 1 week. The emphasis is placed on full and complete blinks, with a relaxed and light appearance that looks natural, without involving the muscles of the eyebrows or cheeks. Blinks should be rapid, taking about a third of a second to complete.

Obviously patient education is key in encouraging patients to carry out the exercises. It is important to make the patient aware of the significance of the problem of incomplete blinking and the advantages to be gained from carrying out the exercises. This can be aided by showing photographs such as that in Figure 3. McMonnies has developed a take-home leaflet for his patients, the Blink Instruction Guide, which contains explanations and illustrations of why efficient blinking is important, as well as instructions for how to carry out blinking efficiency exercises.

Other management strategies for the signs and the symptoms of dryness include recommending artificial tear substitutes and/or contact lens rewetting drops. McMonnies suggests that carrying out blink efficiency exercises immediately after drop instillation will allow the upper lid margin to have the effect of massaging the lubricant drops onto the ocular surface and increasing the benefit of these drops in aiding the healing of exposure keratopathy.

In contact lens wearers it is important in the management of dryness and incomplete blinking not to ignore the obvious possibility of improving the contact lens material where appropriate. Solutions may include switching to more frequent replacement lenses to ensure the lens maintains minimal levels of surface deposits, using a material with enhanced wettability and lubricity, and ensuring an efficient cleaning regime.

Factors that may contribute to increased rates of incomplete blinking

- Provocative environmental conditions (air conditioning, central heating, smoky atmosphere)
- Fatigue
- Mental alertness
- Computer use
- Increased difficulty of visual task
- Refractive surgery
- Contact lenses

Table 2: Conditions influencing incomplete blinking

Summary

The awareness of the need for regular and complete blinking to maintain the health and comfort of the eye should not be underestimated. In the consulting room complaints of ocular discomfort associated with dryness amongst both contact lens wearers and non contact lens wearers are all too common. The blink mechanism plays an important role in moisturising the eye and any reduction in blink rate or blink efficiency is likely to result in an increased rate of reported symptoms. People at greatest risk of problems are those involved in low blink rate activities such as reading and computer use. Where incomplete blinking appears to be implicated as the cause of problems, blinking efficiency exercises may offer a prospect for relief from ocular discomfort. The therapeutic effect of tear lubricants and blinking efficiency exercises may be enhanced when combined.

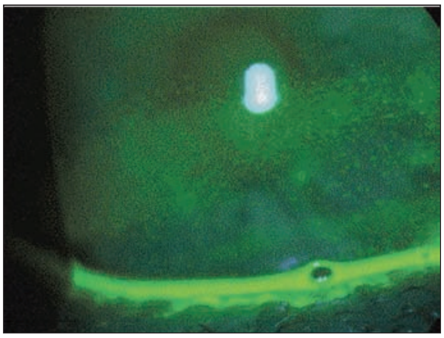

Figure 3: Fluorescein staining highlighting the exposure keratopathy that can result from incomplete blinking
(courtesy of Trusit Dave)

Acknowledgements

Thank you to Dr Kathy Osborn for her expert review.

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An educational initiative supported by Johnson & Johnson Vision Care Institute and Johnson Medical Limited.