Contact Lens Technologies
Created for Tear Film
Stability and Comfort

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More than 140 million people wear contact lenses worldwide, and it is estimated that up to 50% of contact lens wearers experience lens discomfort. When contact lens discomfort (CLD) persists, patients likely reduce the number of hours per day that they wear their lenses or begin wearing them less frequently and ultimately may discontinue lens wear altogether. Several reports have shown that CLD is the primary reason why patients drop out of contact lenses.

Patients describe CLD in different ways: lens dryness, irritation, discomfort, fatigue, etc. While these symptoms often increase as the day goes on, they typically disappear once the contact lens is removed. Although patients often describe CLD as 'dryness', it is separate from dry eye disease and has been defined as “episodic or persistent adverse ocular sensations related to lens wear, either with or without visual disturbance, resulting from reduced compatibility between the contact lens and the ocular environment, which can lead to decreased wearing time and discontinuation of contact lens wear.”

While it is difficult to identify a direct cause for CLD, tear film stability is consistently recognized as a key factor. Therefore, understanding the tear film and taking steps to maintain the normal function of the tears, while in the presence of a contact lens, is critical.
Tear Film Structure and Function

A healthy tear film provides several functions to the ocular surface: 1) maintains a smooth optical surface, 2) lubricates to reduce friction with the eyelids, and 3) provides nutrients and microbial protection. It consists of two layers: the inner mucoaqueous layer and the outer lipid layer. The mucoaqueous layer provides the bulk of the tear volume and directly protects ocular surface cells, while the main role of the lipid layer has been thought to minimize tear evaporation and stabilize the overall tear film. However, it is likely that both tear film layers contribute to the latter and, more specifically, the interactions between the two layers that allows this to happen.

The tear film lipid layer is a bilayer that contains multiple classes of both non-polar and polar lipids (Figure 1). The non-polar lipids create an outer layer and the polar lipids create an inner layer. The outer non-polar lipids act as a barrier to prevent evaporation and disruptions in the tear film. The inner polar lipids are important for maintaining structural stability by anchoring the outer non-polar lipids to the underlying mucoaqueous layer. The non-polar lipids help lower surface tension allowing for the outer non-polar lipids to evenly spread and ultimately reduce evaporation.

The inner polar lipids mainly consist of phospholipids and hydroxy fatty acids. The predominant phospholipid found within the tears is phosphatidylcholine, while the main fatty acid is (O-acyl)-ω-hydroxy fatty acid. When there are deficiencies of phospholipids and/or hydroxyl fatty acids, the lipid layer cannot attach properly to the underlying mucoaqueous layer or spread over the surface appropriately leading to disruption of the tear film, tear evaporation, and potential eye discomfort and visual disturbances.

FIGURE 1: OUTER LIPID BILAYER OF THE TEAR FILM
Clinical View

Tear film Stability

Visualizing the tear film is critical for understanding the status and dynamics of the tears. Several methods can be used for assessing tear film stability, with the most common being sodium fluorescein (NaFl) assisted tear break up time (TBUT) and non-invasive tear break up time (NITBUT) using ring mires or interferometry. Non-invasive measures are preferred when possible since they do not induce reflex tearing and do not alter the tear structure as is the case with NaFl. Non-invasive measures also make it possible to view tear film stability over a contact lens, which is essential.

When using the ring mire method, a stable tear film will have perfectly spaced and non-distorted mires, while an unstable tear film will show uneven spacing and distorted mires (Figure 2). This type of assessment makes it easy to understand how an unstable tear film, which creates areas of non-wetting (or dryness), can cause decreased visual quality and ultimately discomfort. 9,14

FIGURE 2: NON-INVASIVE TEAR BREAK UP OF A) STABLE TEAR FILM VS B) UNSTABLE TEAR FILM

Tear Film with a Contact Lens

Contact lens wear poses significant challenges for the tear film as it interacts with the mucoaqueous and lipid components of the tears, and inherently disrupts the tear film. When placed on the eye, a contact lens causes the structure and composition of the tear film to change in several ways: 1) the tear film is physically divided into a pre-lens layer and post-lens layer (Figure 3) and 2) the pre-lens layer, which now serves as the surface layer, has less mucoaqueous tear volume and a thinner lipid layer. These changes leave the tears more susceptible to increased tear evaporation, reduced tear break up time and tear film instability, which ultimately have been associated with reduced comfort and visual quality. 14

Contact lens wear has also shown to decrease the amount of phospholipids in the tears. The reduced levels may be due to deposition onto the lens surface,9,15 depleting them from the surrounding tear film, and also causing a source for further tear film disruption. Reduced amounts of phospholipids have been found to be associated with shorter tear breakup times among soft contact lens wearers.9,16 Additionally, a reduction in both phospholipids and hydroxy fatty acids have been associated with CLD.14

Successful contact lens wear depends on a stable tear film, meaning that the contact lens needs to cause minimal disruption to the ocular surface. A stable tear film is essential for good visual quality and for lens comfort.
Management of CLD

When patients present with symptoms of CLD, which are not linked to defects in the lens or to the fitting relationship of the lens to the cornea, there are several management options that can help promote tear film stability and improve comfort. A change in lens care solution could help provide relief, particularly if it is a solution that contains a wetting agent. While the lens soaks in solution overnight, wetting agents can interact with and adsorb onto the contact lens surface making it more hydrophilic/wettable and improving tear film stability and comfort. Hydrogen peroxide systems may be less disruptive to the tear film than MPS solutions since they do not contain preservatives and could be less irritating to individuals who are sensitive to preservatives in MPS solutions. Adjusting the frequency of lens replacement can also benefit comfort. The longer a lens is worn, the more likely it is to lose its surface wettability, mainly due to deposits, creating dry areas that reduce tear film stability and comfort. The most ideal replacement schedule, in this regard, is daily disposable replacement, where there is little chance for surface deposit build up and the potential effects of lens care solutions are eliminated. Compliance can also play a role in CLD symptoms, particularly if patients are not cleaning/rubbing the lens properly and/or not replacing the lenses at appropriate intervals. Again, daily disposable lenses help to eliminate these factors, and it has been shown that patients are more compliant with the manufacturer recommended replacement schedule in this modality. Lastly, lens technologies are important to consider when selecting a lens for patients since they are designed to specifically support the tear film and provide comfort.

Given that the stability of the tears is reduced in the presence of a contact lens and that maintaining tear film stability is a key factor for contact lens comfort and visual quality, advancements in contact lens materials and technologies have focused on addressing this specific issue. The most common examples are the use of surface treatments and wetting agents (i.e. surfactants). The function of both are two-fold: 1) make the lens surface more hydrophilic which attracts and holds moisture to the surface and 2) decrease the amount of deposits on the lens surface, which minimizes their disruptive interactions with the tears. Wetting agents can be incorporated in several ways: in the blister pack solution, bound on the surface or within the lens matrix, or released from the contact lens during wear. More recent advancements have gone beyond these typical technologies to include novel water-gradient material designs and the incorporation of phospholipid to help stabilize the lipid layer of the tear film.

Awareness of available contact lens technologies and understanding how they benefit the tears over the surface of the lens is important as this can help prevent contact lens discomfort and drive successful contact lens wear. There are daily disposable lens options that have been designed with unique technologies to specifically support tear film stability, comfort and visual quality.
Alcon DAILIES® Brand Contact Lenses

DAILIES TOTAL1® Contact Lenses

DAILIES TOTAL1® (delefilcon A) contact lenses are daily disposable lenses that have a novel water gradient lens surface that is unlike any other lens currently on the market. While the core of the lens is silicone hydrogel and exhibits typical features such as high oxygen permeability and low water content (33%), the unique water gradient technology forms an outer hydrophilic gel layer allowing the surface of the lens to have high water content (>80%)\(^{23}\) (Figure 4). The water gradient is not simply a surface treatment, but instead is integrated into the bulk lens material. The material is so unique that it does not easily fit into traditional lens categorizations— it is not simply a silicone hydrogel lens as it has characteristics of both hydrogel and silicone hydrogel lenses.\(^{24}\)

DAILIES TOTAL1® contact lenses also feature another novel technology called SmarTears® Technology, in which the lens releases phosphatidylcholine (PC), a polar phospholipid discussed earlier that is found naturally in the tears. PC in the tears is important to help stabilize the lipid layer of the tear film in order to help prevent tear film evaporation. The release of this ingredient from the contact lens is not continuous, but instead is based on diffusion and the concentration of PC in the surrounding tear film throughout the day.\(^{25}\)

The water gradient and SmarTears® Technologies are both novel and unique and, together, create a highly wettable lens surface (shown to last the entire day of wear) that supports tear film stability, and ultimately provides exceptional lens comfort and visual quality for patients.\(^{26-30}\)

**FIGURE 4: DAILIES TOTAL1® TECHNOLOGIES**

- **Water Gradient Technology**
  Nearly 100% WATER at the surface, so all that touches the eye is a cushion of moisture\(^{23}\)

- **SmarTears® Technology**
  Lens release phosphatidylcholine (PC), an ingredient found naturally in tears that helps to stabilize the lipid layer of the tear film\(^{25,26}\)
DAILIES® AquaComfort Plus® Contact Lenses

DAILIES® AquaComfort Plus® (nellficon A) contact lenses are hydrogel daily disposable lenses that are made of a material containing a hydrophilic polymer called polyvinyl alcohol (PVA), with 69% water content. This polymer is unique in that it allows for the sustained release of PVA throughout the day, a technology called Blink Activated Moisture.

The lenses contain 3 different moisturizing agents designed to continuously support tear film stability and provide comfort throughout the day:

1. HPMC (hydroxypropyl methylcellulose) is added to the blister pack solution and enhances comfort upon insertion.
2. PEG (polyethylene glycol) has also been added to the blister pack solution and is an ingredient commonly used in lubricating eye drops. This moisturizing agent is taken up by the lens surface and released from the contact lens during the early part of the day.
3. PVA (polyvinyl alcohol) is incorporated into the lens matrix in bound and unbound versions. The bound version is permanently crosslinked within the matrix, while the unbound version is free to be released slowly and continuously into the tears throughout the day using the forces of the lid during blinking (Figure 5). PVA is a successful tear film stabilizer that is widely used in lubricating eye drops and has been shown to improve tear break-up time.

When compared to the leading daily disposable lens, DAILIES® AquaComfort Plus® has shown a more stable non-invasive tear break-up time over the surface of the lens (Figure 6). The combination of moisturizing agents, along with the Blink Activated Moisture technology, help to stabilize the tear film and support clear vision, wettability and comfort throughout the day.

Summary

CLD affects up to 50% of contact lens wearers and a key contributing factor to this is tear film instability. The physical presence of a contact lens on the eye causes structural changes to the tears making them more susceptible to evaporation and instability, which then can lead to discomfort and reduced visual quality. Successful contact lens wear relies on maximizing normal tear function over the surface of the contact lens, making the use of lens technologies that specifically support tear film stability and comfort critical.