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## The eyelids and tear film in contact lens discomfort

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## ABSTRACT

**Purpose:** To investigate characteristics of the eyelid margins, meibomian glands and the tear film of contact lens wearers, and to determine whether these characteristics were related to symptoms of contact lens discomfort.

**Methods:** A cross sectional study was performed on thirty existing daily wear soft contact lens wearers (6 male; 24 female) with median age of 23 years (range 18–41). Eyelid signs and tear film characteristics were evaluated during a single visit and subjects completed the contact lens and dry eye questionnaire (CLDEQ-8) to evaluate ocular discomfort.

**Results:** Based on the CLDEQ-8 responses, subjects were classified as symptomatic ( $n = 17$ ) or asymptomatic ( $n = 13$ ). Grades of foam at meibomian gland orifices ( $3 \pm 1$ ), expressibility ( $2 \pm 1$ ) and quality of secretions ( $2 \pm 1$ ), tear evaporation rate with ( $112 \pm 54 \text{ g/m}^2/\text{h}$ ) or without ( $88 \pm 45 \text{ g/m}^2/\text{h}$ ) contact lens wear, fluorescein tear breakup time ( $8 \pm 2$  seconds) and tear lipid layer thickness ( $45 \pm 17 \text{ nm}$ ) were significantly associated with symptoms of discomfort in symptomatic lens wearers only ( $r^2 > 0.45$ ;  $p$  value  $< 0.05$ ). Upper lid-wiper epitheliopathy, meibomian gland acini reflectivity and tear meniscus height showed significant correlations with comfort scores in both symptomatic and asymptomatic contact lens wearers ( $p < 0.05$ ). A greater number of Demodex mites was also observed in the upper eyelid of symptomatic lens wearers ( $2 \pm 1$ ) compared to asymptomatic lens wearers ( $0 \pm 0$ ;  $p$  value = 0.042).

**Conclusions:** Morphological irregularities of the meibomian glands and alterations to tear film secretions that affect tear evaporative dynamics were associated with symptoms of discomfort amongst the symptomatic lens wearers.

## 1. Introduction

Approximately 140–150 million people wear contact lenses globally [1–3]. Of these, 50% experience discomfort during lens wear and at least 25% of wearers are likely to discontinue lens wear permanently [4,5]. Dynamic interactions of eyelids and contact lenses with every blink could potentially be involved in contact lens discomfort [6–8].

Pult et al. [9] observed significantly higher grades of lid wiper epitheliopathy and lid parallel conjunctival folds (LIPCOFs) in contact lens wearers with dry eye symptoms. Increased LIPCOF severity scores and decreased non-invasive tear breakup time were also the most predictive for symptoms in lens wearers [10]. In contrast, some studies have reported that lid wiper epitheliopathy did not correlate with comfort scores in lens wearers [11–13]. Contact lens wearers demonstrate a greater incidence of meibomian gland dysfunction (MGD) [14–17]. Association between MGD and ocular symptoms in lens wearers couldn't be established due to marked variability from individual to individual [15]. Although studies have shown relationship

between subjective symptoms and contact lens wear [14,18], few others have found that symptoms did not vary significantly between lens wearers and non-lens wearers [19,20]. Ocular *Demodex* especially, *Demodex folliculorum* in eyelash follicles and *Demodex brevis* in meibomian glands, have been associated with morbidities such as anterior blepharitis, posterior blepharitis involving meibomian gland dysfunction [21,22]. Increase in the numbers of *Demodex* caused an increase in subjective ocular surface symptoms [21]. Furthermore, *Demodex* mites also occur in up to 90% of contact lens wearers; however no association with comfort was established in that study [23].

Young et al. [24] reported that there was no significant difference in symptoms between groups that had different grades of meibomian gland expressibility, while a study by Villani et al. [25] and Pucker et al. [20] demonstrated that contact lens wearers reporting discomfort had compromised meibomian gland expressibility patterns and meibomian gland morphological changes. No difference has been observed in symptoms experienced by lens wearers and age-matched non-contact lens wearers [19,20], but significant associations between higher

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meibum quality score, frequent bulbar and palpebral conjunctival hyperemia, presence of lid margin telangiectasia, rounding, notching and hyperemia of the posterior lid margin, higher grades of orifice plugging and retroplacement of Marx's line have been observed during contact lens use [17–20,26,27]. Studies have also shown that symptoms in contact lens wearers are ameliorated by improvement in eyelid hygiene, indicating the importance of eyelid health and its impact on ocular symptomatology in lens wear [28,29].

Non-invasive tear breakup time and tear meniscus height differ significantly among current contact lens wearers, non-lens wearers and previous contact lens wearers [27,30,31]. Glasson et al. [32] found that the strongest associations with intolerance to contact lens wear were with non-invasive breakup time and lack of tear film volume. Clinical variables such as lid-wiper epitheliopathy, lid parallel conjunctival folds, expressibility of meibomian gland secretions, tear break up time and the meniscus height/area, have been shown to predict contact lens discomfort [33,34]. Nevertheless, the underlying pathophysiology of contact lens discomfort still not fully elucidated and discrepancies with the association of eyelids, meibomian glands and tear film variables with symptoms in contact lens wear still persist. The purpose of the current study was to compare structural differences in the eyelid margins, meibomian glands and the tear film of symptomatic and asymptomatic contact lens wearers, and to determine whether any of these variables were related to symptoms of contact lens discomfort.

## 2. Materials and methods

All procedures were conducted in accordance with the Declaration of Helsinki (1983), and the study was approved by the Human Research Ethics Committee, University of New South Wales, Sydney, Australia. All subjects provided signed informed consent before being enrolled in the study.

Thirty healthy contact lens wearers (6 male; 24 female) with a median age of 23 years (range 18–41), who had worn contact lens for at least 6 months, used lenses for at least 3 weeks before the evaluation visit and wore lenses for at least four times a week, were enrolled in the study. All contact lenses were worn on a daily wear modality. Exclusion criteria included (i) subjects with corneal fluorescein staining (type, depth and extent) of grade 1 or more based on CCLRU grading scales [35], (ii) subjects who had corneal opacities and/or vascularization of grade 1 or more based on CCLRU grading scales [35], (iii) subjects with any history of any ocular or systemic diseases that might influence the tear film, (iv) the use of any ocular and/or systemic medication, (v) subjects with epilepsy as there would be exposure to flashing lights during the Lipi-view examination (Tear Science<sup>®</sup>, Morrisville, NC) and (vi) evidence of conjunctival abnormalities such as pterygium or pinguecula. All participants were assessed to ensure that their habitual lenses were of acceptable fitting and all subjects in this study wore optimally fitting lenses. Eyelid signs and tear film characteristics were evaluated during a single visit and subjects were asked to complete the contact lens and dry eye questionnaire (CLDEQ-8). All measurements were conducted on the right eye only, except tear osmolarity measurements, for which measurements were recorded for both eyes and the average was considered for analysis. Measurements of all the study variables were performed without contact lenses except for tear evaporation rate, which was assessed both with and without contact lenses. The order of investigations conducted ranged from least invasive to the most invasive procedure.

### 2.1. Eyelids

Lid-wiper epitheliopathy was observed by slit lamp biomicroscopy after staining the marginal conjunctiva with a combination of 2% (w/v) sodium fluorescein (Fluor-I-strip A.T. ophthalmic strips 1 mg, Wyeth-Ayerst Laboratories, Rouses Point, NY) and 1% (w/v) lissamine green (OpGreen 1.5 mg, Ophthentics Unlimited, India). Staining of the lid-

wiper region was graded based on the classification devised by Korb et al. [36].

Grading of the lid parallel conjunctival folds (LIPCOFs) [9,10,37,38] and other eyelid margin signs such as ridging of Marx's line, anterior blepharitis, hyperkeratinisation, telangiectasia, lash loss, eyelid vascularity, irregularity or notching of eyelids, rounding of posterior margin (posterior borders of tarso conjunctival layers are normally sharp), redness and thickness of lid margin and lash contamination was based on previously published standardized grading scales [39].

Eyelid sensitivity was assessed using a Cochet-Bonnet aesthesiometer (Luneau Ophthalmologie, Chartres, France). The length of this filament can be varied so that touch pressure applied to the ocular surface is altered. The length where the subject could first perceive the touch of the filament was recorded and then converted to pressure (g/mm<sup>2</sup>) [40]. An ascending method of limits was employed to determine the threshold to stimulation. Thresholds were then converted to sensitivity for analysis by taking the inverse of threshold values [40].

Laser scanning confocal microscopy was performed with the Heidelberg Retinal Tomographer II (HRT II) using a Rostock Corneal Module attachment (Heidelberg Engineering GmbH, Heidelberg, Germany) to observe and record *Demodex* colonization of the eyelids. Digital images of the underlying follicles of three central, three nasal and three temporal eyelashes were captured along with the corresponding meibomian glands (Fig. 1). The sum of the *Demodex* counts was recorded for each participant [23].

Meibomian gland morphology was assessed using the Oculus Keratograph 5 M Meibo-Scan (Oculus Optikgerate GmbH, Wetzlar, Germany), a slit lamp unit equipped with an infrared charge-coupled device video camera and an infrared transmitting filter. Meibomian gland signs were then graded based on the previously published meiboscore grading scales [39,41]. Images of meibomian gland acini were captured using confocal microscopy with the Heidelberg Retinal Tomographer II (HRT II) using the Rostock Corneal Module attachment and used to grade the reflectivity in the gland acini for secretion quality [25]. The palpebral conjunctiva of the upper and lower eyelids (after inversion) were assessed using slit lamp bio-microscopy, to record roughness, redness (hyperemia) and staining based on the CCLRU grading scales [35].

### 2.2. Tear film

Tear volume was measured using a phenol red thread (Zone Quick, Showa Yakuhin Kako Co., Ltd, Japan) of 75 mm length. The wet length of the thread 15 s after insertion into the lower tear meniscus was recorded. Tear meniscus height was measured from images captured using the Oculus Keratograph 5 M (Oculus Optikgerate GmbH, Wetzlar, Germany) as the distance between the darker edge of the lower eyelid and the top of the reflex from the tear strip [42].

The thickness of tear lipid layer was assessed using a Lipi-View Interferometer (Tear Science<sup>®</sup>, Morrisville, NC) and recorded in nanometres. Invasive tear breakup time was measured once by recording the time taken (in seconds) for any dry spot to form over the tear film following the last blink after staining the ocular surface with 1% fluorescein.

The evaporation rate of the tears on the ocular surface was measured as described previously using a modified Vapometer (Delfin Technologies, Kuopio, Finland) [43]. To minimize the bias of skin evaporation around the eyelids and skin below the lower eyelids, petroleum jelly (Vaseline<sup>®</sup> Unilever, Australia) was applied over the upper and lower eyelids, and skin around the eyelids. The Vapometer was then placed on the right eye of the participant and evaporation rate measured. Care was taken to restrict participants from blinking during the measurement. Measurements were also taken with eyes closed to account for any contribution of evaporation from the skin. Three consecutive measurements were taken with the eyes open and eyes closed, and the average of these values was calculated. Measurements were

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