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The relationship between the eyelid status and contact lens discomfort

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ABSTRACT

Purpose: To study the relationship between eyelid alterations and the presence of contact lens discomfort (CLD) in soft contact lens (CL) wearers.
Methods: One hundred thirty-seven CL wearers were included in this cross-sectional study. CLD symptoms were quantified by the Contact Lens Dry Eye Questionnaire (CLDEQ)-8. Participants were also classified considering the CLD effect on wearing time. Non-invasive tear break-up time was measured with the EasyTear® VIEW + Tearscope, tear film lipid layer thickness was assessed with the LipiView II interferometer, and lid margin parameters, Meibomian gland morphology and function, and lid wiper epitheliopathy were evaluated using slit-lamp biomicroscopy (SL-D7, Topcon corp.). Correlations between symptoms and signs were analysed, and multivariable regression models were performed.
Results: Lid margin thickness ($p = 0.07$), Meibomian gland secretion quality ($p = 0.02$) and expressibility ($p = 0.09$) showed a significant ($p \leq 0.1$) simple association with the CLD effect classification, but only lid margin thickness reached statistical significance in the multivariable regression model [odds ratio (95 % confidence interval): 0.52 (0.30/0.87); $p = 0.015$]. No significant ($p \leq 0.05$) simple linear association was found between the CLDEQ-8 and any of the ocular parameters.
Conclusions: The presence of mild CLD symptoms in soft CL wearers was not consistently associated with any eyelid alteration, except for lid margin thickness. Future studies assessing the impact of lid margin thickness on CLD would be valuable.

1. Introduction

The eyelid plays a key role in maintaining the integrity of the ocular surface. Glands located in the lid margin secrete several components of the tear film allowing adequate tear film distribution [1]. Therefore, deterioration of the lid margin has been associated with ocular surface damage [2]. Meibomian gland (MG) dysfunction is one of the most frequent conditions observed during routine optometric consultations [3]. This condition results in thinning of the tear film lipid layer, which leads to tear film instability and increased evaporation of the aqueous phase of the tear film, resulting in evaporative dry eye disease [3,4].

MG alterations such as MG loss or plugging of the MG orifices have been observed more frequently in contact lens (CL) wearers, in addition to other alterations of the lid margin such as vascularity, irregularity, roundness, or displacement of the Marx's line [5–9]. Indeed, the dynamic interaction of CLs with the eyelids in each blink could be involved in CL discomfort (CLD) [10,11]. CLD symptoms have been found to improve after the performance of eyelid hygiene, highlighting the importance of eyelid health and its implications in CLD symptomatology [12]. In addition, several eyelid alterations have been reported to be good predictors of CLD symptoms, such as pouting and capping of the MG orifices, alterations of the quality and quantity of MG secretions and the expressibility, tarsal redness, and tarsal roughness [13].

On the one hand, many eyelid alterations, such as narrowing of the MG orifices, Marx's line ridging, MG positioning posterior to the Marx's line, trichiasis, and madarosis, have been described [14]. However,

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studies concerning CL wear and discomfort do not include many of these alterations. On the other hand, no consistent association between the signs and symptoms of CLD has been found [15,16]. Therefore, further large-sample studies analysing these relationships are still required. Thus, the purpose of this study was to investigate the relationship between eyelid alterations and the presence of CLD in a representative sample of soft CL wearers.

2. Methods

A cross-sectional, observational study was conducted to evaluate the eyelid status in CL wearers with and without discomfort symptoms. It was approved by the East Valladolid Health Area Ethics Committee (Valladolid, Spain) (July 23, 2020; Reference: PI 20–1909) and followed the tenets of the Declaration of Helsinki. Prior to inclusion in the study, its nature was explained to all participants and written informed consent was obtained.

2.1. Participants

Current CL wearers, who started wearing CLs at least one year ago and were over 18 years old, were consecutively included in the study. Participants wearing rigid (including corneal, mini-scleral, scleral, and *ortho*-k CLs) or conventional replacement hydrogel CLs were excluded, as were participants presenting any disease or allergy contraindicating CL wear, any systemic treatment affecting the ocular surface, any corneal ectasia or previous ocular surgery, any topical treatment other than artificial tears, pregnancy or breastfeeding. CL wearers were clinically evaluated in a single visit while wearing the CLs. Although both eyes were evaluated, one eye per subject was randomly selected for the statistical analysis.

2.2. Symptoms assessment

CLD symptomatology was quantified using the Contact Lens Dry Eye Questionnaire (CLDEQ)-8 [17] (copyright Begley & Chalmers 2016, with permission), whose cut-off value is $\geq$ 12 (range, 1 to 37) [18]. Finally, based on the Tear Film and Ocular Surface Society (TFOS) CLD progression classification [19], participants were classified into three groups based on the effect of CLD on wearing time: (1) no effect, (2) reduction in comfortable CL wearing time and (3) reduction in total CL wearing time [20].

2.3. Clinical evaluation

The 100 % contrast monocular visual acuity was measured with the CLs on [logarithm of the minimum angle of resolution (logMAR) scale]. The average of 3 non-invasive tear break-up time (NIBUT) measurements obtained with the EasyTear® VIEW + Tearscope (EASYTEAR s.r. l., Trento, Italy) with the CLs on was recorded. Tear film lipid layer thickness was evaluated with the LipiView II interferometer (Johnson & Johnson Vision, Santa Ana, CA, USA). The lid margin was examined using a slit lamp (SL-D7, Topcon corporation). Lid margin thickness was evaluated using a 0–5 scale (0: normality; 5: the highest severity score) [14]. The antero- and *retro*-placement of the Marx's line, chalazion, MG positioning posterior to the Marx's line, eyelid concretions, MG quality of secretions and MG expressibility, were evaluated using a 0–3 scale (0: normality; 3: the highest severity score) [14]. The presence or absence (presence = 1; absence = 0) of lid margin roundness, lid margin irregularity, lid margin telangiectasias, trichiasis, madarosis, lid margin malposition, Marx's line ridging, pouting and capping of the MG orifices, loss of lid margin definition, MG orifice vascularisation and narrowing, and foamy MG secretions were also evaluated [14]. Tarsal hyperemia and papillae were measured using the Cornea and Contact Lens Research Unit (CCLRU) scale (1–4) [21]. Lid wiper epitheliopathy (LWE) was evaluated after the instillation of 5 μL of 2 % sodium fluorescein and lissamine green strips (I-DEW FLO and I-DEW GREEN; Entod Research Cell, London, UK) which were wetted with 25 μL of sodium chloride into the inferior fornix. The final value was the mean of the horizontal length (0–3) and the sagittal height (0–3) stainings [11]. Finally, meibography images of the upper and lower eyelids were obtained using the LipiView II interferometer (Johnson & Johnson Vision, Santa Ana, CA, USA). The percentage of MG loss and tortuosity of the central 2/3 area of the eyelids was evaluated using ImageJ software, as previously detailed in the literature [22].

2.4. Statistical analysis

Statistical analysis was performed using the Statistical Software for the Social Sciences for Windows version 26.0 (IBM SPSS Statistics, IBM Corp., Armonk, NY, USA). Sample size was estimated to detect an effect size of 0.3 for the Pearson's correlation coefficient (determined as a medium effect size by Cohen) [23], with a significance level of 0.05 and a statistical power of 95 %. The minimum sample size required was 138 participants.

The assumption of normal distribution for quantitative variables was checked using the Kolmogorov-Smirnov test. Descriptive variables were compared between the asymptomatic and symptomatic groups using the Student's *T*-test (for normally distributed quantitative variables), the Mann-Whitney *U* test (for non-normally distributed quantitative and ordinal variables), the Chi-squared test (for qualitative variables with at least 80 % of expected frequencies above 5) or the Fisher's exact test (for qualitative variables not meeting the criterion of expected frequencies).

Correlations between the scores obtained in the symptom questionnaires and the eyelid parameters were analysed using Pearson's correlation coefficient (for normally distributed quantitative variables), Spearman's correlation coefficient (for non-normally distributed quantitative or ordinal variables), or the rank-biserial correlation (for a dichotomous variable and a quantitative or ordinal variable). Variables whose representation was almost unique at one level (>95 %) were excluded from the correlation analysis because these will not be useful for detecting CLD. Variables significantly correlated or close to significance (<0.1) were further analysed using multivariable ordinal regression models. The assumptions of proportional odds and lack of multicollinearity were checked.

3. Results

A total of 137 current CL wearers (50 males and 87 females; 89 asymptomatic and 48 symptomatic) were included in the study. Most of the participants (51.8 %) wore reusable (biweekly, monthly, or quarterly replacements) silicone hydrogel CLs, while the remaining participants wore other types of CLs: 15.3 % wore reusable hydrogel CLs, 11.7 % used daily disposable hydrogel CLs, and 21.2 % used daily disposable silicone hydrogel CLs. As shown in Table 1, no differences were found for any of the descriptive variables between the asymptomatic and symptomatic groups, except for all the symptom questionnaires evaluated.

Table 2 shows the values obtained for each eyelid parameter evaluated in the entire sample of soft CL wearers. There was a significant negative correlation between the CLD effect on wearing time and MG secretion quality ($p = 0.026$) (Table 3). For the classification of the CLD effect, three parameters (lid margin thickness, MG secretion quality, and MG expressibility) were considered in the regression model because they were significantly correlated or showed a trend towards significance ($p < 0.1$). However, only lid margin thickness reached statistical significance [odds ratio (95 % confidence interval): 0.52 (0.30/0.87); $p = 0.015$]. Fig. S1 (Supplementary Material) shows the distribution of the variables considered in the regression model.

Table 1
Descriptive data of the whole sample and the asymptomatic and symptomatic groups.

	Whole sample	Asymptomatic group	Symptomatic group	p-value
Age (years old)	33.1 ± 11.9	33.9 ± 13.1	31.6 ± 9.3	0.786[a]
Sex (%, male/female)	36.5/63.5	41.6/58.4	27.1/72.9	0.093[b]
CL type (%, hydrogel/silicone hydrogel)	27.0/73.0	25.8/74.2	29.2/70.8	0.676[b]
CL replacement (%, daily/frequent)	32.8/67.2	28.1/71.9	41.7/58.3	0.106[b]
CL spherical equivalent (D)	−3.84 ± 2.87	−4.09 ± 3.10	−3.39 ± 2.34	0.327[a]
CL wearing time (years)	14.9 ± 10.0	15.3 ± 10.7	14.1 ± 8.7	0.857[a]
Days/week of CL wear	5.1 ± 2.1	5.3 ± 1.9	4.7 ± 2.4	0.192[a]
Hours/day of CL wear	8.8 ± 3.7	8.9 ± 3.9	8.6 ± 3.3	0.835[a]
Visual acuity (logMAR scale)	−0.05 ± 0.12	−0.04 ± 0.13	−0.06 ± 0.11	0.321[a]
CLDEQ-8	9.9 ± 7.5	5.3 ± 3.4	18.5 ± 4.9	**<0.001**[a]
CLD effect on wearing time	2 [1–2]	1 [1–2]	2 [2–3]	**<0.001**[a]

Data are presented as mean ± standard deviation for quantitative variables, percentage for qualitative variables, and median [interquartile range] for ordinal variables. Frequent replacement represents biweekly, monthly, and quarterly replacements. P-values refer to the comparison between the asymptomatic and symptomatic groups. CL: contact lens; D: dioptres; CLD: contact lens discomfort; CLDEQ: Contact Lens Dry Eye Questionnaire. [a] Mann-Whitney *U* test; [b] Chi-squared test.

4. Discussion

Proper eyelid health is highly recommended for successful CL wear. The lid margin plays a key role in maintaining the integrity of the ocular surface and a steady dynamic interaction of the eyelids with the CLs occurs in each blink [1,9,11]. As such, several morphological and functional eyelid alterations have been associated with the development of CLD symptoms [7,11,13]. New technological advancements and the development of new clinical tests allow clinicians to obtain objective and reliable measurements of many different parameters associated with the eyelids; thus, a comprehensive association with CLD is still required. However, evaluating a wide range of parameters in clinical practice is difficult due to time constraints. Therefore, it is important for clinicians to know which parameters are related to CLD to avoid time-consuming tests. This study presents a comprehensive clinical evaluation of the eyelids of CL wearers with and without discomfort symptoms, and found no general relationship between the degree of CLD symptoms and eyelid alterations, except for lid margin thickness.

The mean age (33.1 ± 11.9 years old) and percentage of women (63.5 %) of the sample included in this study was very similar to that reported globally in the CL wearer population (33.7 ± 15.9 years old and 65 % of women) [24]. Similarly, the most frequent CL fits were reusable silicone hydrogel CLs [24]. The average CL wearing time of the participants included in the present study (5.1 ± 2.1 days/week and 8.8 ± 3.7 h/day) indicates that they were regular CL wearers. As shown in Table 1, no differences were found between the asymptomatic and symptomatic groups in terms of CL wearing characteristics and usage (CL type, replacement, and wearing time), but there were differences in the scores of the CL symptom questionnaires. This finding suggests that the sample recruited is representative from the global population of CL wearers.

Table 2
Values obtained for each eyelid parameter evaluated in the entire sample of soft contact lens wearers.

Eyelid parameter	Whole sample
Upper lid MG loss (%)	15.9 ± 9.6 (min: 0.0, max: 47.2)
Upper lid MG tortuosity (%)	72.1 ± 18.6 (min: 12.5, max: 100.0)
Lower lid MG loss (%)	5.5 ± 8.0 (min: 0.0, max: 54.2)
Lower lid MG tortuosity (%)	15.9 ± 18.0 (min: 0.0, max: 75.0)
NIBUT (s)	5.8 ± 4.8 (min: 3.4, max: 24.5)
Lipid layer thickness (nm)	75.2 ± 15.8 (min: 36.0, max: 100.0)
Lid margin thickness (0–5 scale)	0 [0–1] (min: 0, max: 2)
Marx's line anteroplacement (0–3 scale)	0 [0–0] (min: 0, max: 0)
Marx's line retroplacement (0–3 scale)	0 [0–0] (min: 0, max: 0)
Chalazion (0–3 scale)	0 [0–0] (min: 0, max: 2)
MG positioning posterior to the Marx's line (0–3 scale)	0 [0–0] (min: 0, max: 3)
LWE (0–3 scale)	0 [0–0] (min: 0, max: 2)
Tarsal hyperemia (1–4 scale)	1 [1–2] (min: 1, max: 3)
Tarsal papillae (1–4 scale)	1 [1–2] (min: 1, max: 3)
Eyelid concretions (0–3 scale)	0 [0–0] (min: 0, max: 1)
MG secretion quality (0–3 scale)	0 [0–0] (min: 0, max: 1)
MG expressibility (0–3 scale)	0 [0–0] (min: 0, max: 2)
Lid margin roundness (% no/yes)	98.5/1.5
Lid margin irregularity (% no/yes)	41.6/58.4
Lid margin telangiectasias (% no/yes)	43.8/56.2
Trichiasis (% no/yes)	97.1/0.9
Madarosis (% no/yes)	100.0/0.0
Lid margin malposition (% no/yes)	100.0/0.0
Marx's line ridging (% no/yes)	97.8/2.2
Pouting (% no/yes)	89.1/10.9
Capping (% no/yes)	90.5/9.5
Loss of lid margin definition (% no/yes)	97.8/2.2
MG orifice vascularization (% no/yes)	69.3/30.7
MG orifice narrowing (% no/yes)	100.0/0.0
Foamy MG secretion (% no/yes)	99.3/0.7

Data are presented as mean ± standard deviation for quantitative variables, percentage for qualitative variables, and median [interquartile range] for ordinal variables. Minimum (min) and maximum (max) values of the quantitative and ordinal variables are also provided. LWE: lid wiper epitheliopathy; MG: Meibomian gland; NIBUT: non-invasive tear break-up time.

In this study, CLD was quantified using two different classifications and their correlations with clinical signs were analysed. The questionnaire used was the CLDEQ-8. Additionally, it has been recently observed that a 3-category classification system for CLD could provide a better way of identifying the effect of CLD on CL wear than the previously proposed 5-category system [20]. Therefore, the classification of the sample into three groups according to the effect of CLD on both comfortable and total CL wearing time was included: (1) no effect, (2) reduction in comfortable CL wearing time, and (3) reduction in total CL wearing time. The use of two different classifications was motivated by the fact that different questionnaires may evaluate different aspects of CLD. Indeed, the correlations found were different between them. On the one hand, the CLDEQ-8 showed no significant correlations. On the other hand, the 3-category CLD classification system was correlated with MG secretion quality. The degree of association observed (around 0.2) can be considered small [23], which again agrees with previous reports concluding that CLD symptoms are poorly related to clinical signs [15,16]. Only a small proportion of the CL wearers included in the present study experienced severe CLD symptoms according to the CLDEQ-8 questionnaire, with only 35 % of the participants classified as symptomatic. The fact that participants had mild CLD symptoms may be due to the general lack of association found between CLD symptoms and eyelid alterations. However, detecting severe symptoms in CL wearers may be challenging, as they tend to discontinue CL wear without telling their clinician.

Given the limited or lack of relationship frequently reported between

Table 3
Correlations between the values obtained for the eyelid parameters and the contact lens discomfort symptomatology.

	CLDEQ-8		CLD effect on wearing time	
	Correlation coefficient	p-value	Correlation coefficient	p-value
Upper lid MG loss (%)	−0.05 (rho)	0.548	−0.07 (rho)	0.451
Upper lid MG tortuosity (%)	−0.01 (rho)	0.886	−0.05 (rho)	0.544
Lower lid MG loss (%)	0.05 (rho)	0.572	0.12 (rho)	0.147
Lower lid MG tortuosity (%)	−0.01 (rho)	0.927	0.03 (rho)	0.700
NIBUT (s)	0.09 (rho)	0.309	0.05 (rho)	0.586
Lipid layer thickness (nm)	−0.03 (rho)	0.693	−0.04 (rho)	0.603
Lid margin thickness	−0.12 (rho)	0.171	−0.16 (rho)	0.070
LWE	0.15 (rho)	0.073	0.13 (rho)	0.120
Tarsal hyperemia	0.00 (rho)	0.963	−0.02 (rho)	0.785
Tarsal papillae	0.03 (rho)	0.719	−0.05 (rho)	0.544
MG secretion quality	−0.03 (rho)	0.696	−0.19 (rho)	**0.026**
MG expressibility	0.10 (rho)	0.269	0.14 (rho)	0.093
Lid margin irregularity	0.04 (r_{br})	0.663	−0.01 (r_{br})	0.874
Lid margin telangiectasias	0.03 (r_{br})	0.700	−0.11 (r_{br})	0.181
Pouting	−0.01 (r_{br})	0.888	−0.06 (r_{br})	0.515
Capping	−0.02 (r_{br})	0.778	−0.07 (r_{br})	0.440
MG orifice vascularization	−0.07 (r_{br})	0.417	0.02 (r_{br})	0.773

CLD: contact lens discomfort; CLDEQ: Contact Lens Dry Eye Questionnaire; LWE: lid wiper epitheliopathy; MG: Meibomian gland; NIBUT: non-invasive tear break-up time; r: Pearson's coefficient; r_{br}: rank-biserial coefficient; rho: Spearman's coefficient.

symptoms and signs, the combination of several parameters has been proposed for a better diagnosis of CLD [12,13,25,26]. In the present study, the variables that showed significant correlations ($p < 0.1$) with symptoms were further combined by fitting multivariable regression models. Regarding the effect of CLD on CL wearing time, it was inversely associated with lid margin thickness. It seems counterintuitive that lower lid margin thickness values were related to a decrease in CL wearing time due to CLD, as the opposite might be expected [27]. Nonetheless, the levels observed in the study sample for lid margin thickness were quite low (the highest score obtained by the participants was 2 out of 5, with an average score of 0 [0–1] across the entire sample); therefore, the clinical relevance of this finding appears to be negligible. Moreover, there is a paucity of scientific literature on the relationship between lid margin thickness and CLD or other eyelid parameters. However, contrary to initial expectations, it could be argued that lid margin thinning may actually indicate MG atrophy or loss. This would result in reduced lipid production, leading to a weaker tear film, increased tear evaporation, and greater dryness – ultimately exacerbating CLD. Future studies investigating the role of lid margin thickness in CLD in more detail would be of great value.

The main limitation of this study was that a control group composed of non-CL wearers was not included. However, previous studies have already detailed the functional and morphologic changes of the lid margin in the normal population [28]. In addition, the CL wearers included in the study used a wide variety of CL materials, replacement schedules, and wearing times; on the other hand, this fact can also be considered a strength given that the sample recruited was representative of the general population of CL wearers.

In conclusion, the sample recruited in the present study is representative of the general population of CL wearers. The presence of mild CLD symptoms in soft CL wearers was not consistently associated with any eyelid alteration, except for lid margin thickness. Future research involving highly symptomatic CL wearers could help elucidate the relationship between symptoms and eyelid alterations, particularly the relationship found between lid margin thickness and CLD.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clae.2025.102439.

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