

Symptom–Sign Discordance in Dry Eye Disease: Clinical Characteristics and Age-Adjusted Ocular Surface Findings

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Abstract

Background

Dry eye disease (DED) is heterogeneous, and patient-reported symptoms frequently do not correspond to objective ocular surface signs. This study evaluated symptom–sign discordance in patients with DED and characterized discordant clinical phenotypes using an age-aware ocular surface analysis.

Methods

This retrospective cross-sectional study included 120 patients with dry eye symptoms. Participants completed the Ocular Surface Disease Index (OSDI) and 5-item Dry Eye Questionnaire (DEQ-5). Ocular surface evaluation included tear breakup time (TBUT), tear meniscus height (TMH), Schirmer I testing, Oxford staining, meibography-derived meibomian gland loss, and meibomian gland function assessment. Patients were classified into four symptom–sign phenotypes. Because several objective variables were used to define sign status, they were interpreted as phenotype-related clinical characteristics rather than independent predictors. Age-adjusted analyses were performed to account for the confounding effect of age.

Results

The mean age was 48.6 ± 13.2 years, and 78 patients (65.0%) were female. Symptom–sign discordance was observed in 50 patients (41.7%): 28 (23.3%) had a high-symptom/low-sign phenotype and 22 (18.4%) had a low-symptom/high-sign phenotype. OSDI showed weak-to-moderate correlations with TBUT, TMH, and meibomian gland loss. In unadjusted comparisons, the high-symptom/low-sign group had higher meibum quality and expressibility scores, whereas the low-symptom/high-sign group had greater meibomian gland loss and older age. After age adjustment, meibum quality ($p = 0.011$) and expressibility ($p = 0.019$) remained significantly different among phenotypes, whereas meibomian gland loss was attenuated and no longer statistically significant ($p = 0.071$).

Conclusions

Symptom–sign discordance is common in DED. Functional meibomian gland impairment may contribute to high symptom burden despite relatively mild conventional signs, whereas structural gland loss in low-symptom/high-sign patients may be partly age-related. A multimodal, age-aware ocular surface assessment may improve clinical interpretation of dry eye phenotypes.

Background

Dry eye disease (DED) is a multifactorial disorder characterized by tear film instability, hyperosmolarity, ocular surface inflammation, and neurosensory abnormalities [1–3]. In contemporary clinical practice, both subjective symptom scores and objective tests are used to evaluate DED [4]. However, a notable discrepancy is often observed between the severity of patient-reported symptoms and measured ocular surface parameters [5, 6].

This discordance reflects the heterogeneous nature of DED and may be associated with distinct pathophysiological mechanisms, particularly evaporative dry eye, meibomian gland dysfunction (MGD), and neuropathic ocular pain [7–11]. Meibography and standardized meibomian gland assessment permit structural and functional evaluation of MGD, while tear film and ocular surface testing provide complementary information [12–14].

Although symptom–sign discordance in DED has been described previously, its clinical interpretation remains challenging, particularly when structural meibomian gland changes coexist with age-related ocular surface alterations [6, 12, 15]. Therefore, the present study aimed to evaluate the relationship between clinical symptoms and ocular surface parameters in patients with DED and to characterize distinct symptom–sign phenotypes using an age-aware analytical approach.

Methods

Study design and participants

This single-center, retrospective, cross-sectional clinical study screened patients presenting with dry eye symptoms to the Ophthalmology Department of Mersin City Training and Research Hospital between January 1, 2025, and January 1, 2026. The study protocol was approved by the local ethics committee (protocol number 25.03.2026-2026/181), and all procedures were conducted in accordance with the Declaration of Helsinki.

Patients aged ≥ 18 years who reported dry eye symptoms, were able to complete the OSDI and DEQ-5, and underwent a complete ocular surface evaluation were included. An additional inclusion criterion was the absence of any change in dry eye treatment within the preceding month. Exclusion criteria were ocular surgery within the previous 3 months, active ocular infection or inflammation, contact lens wear, ongoing topical glaucoma therapy, significant eyelid malposition, severe allergic conjunctivitis, active autoimmune disease or other systemic conditions that could substantially affect ocular surface measurements, and recent initiation of topical cyclosporine or artificial tear therapy within the previous 3 months.

Symptom assessment and ocular surface evaluation

Participants completed the Turkish versions of the OSDI and DEQ-5 before clinical testing. The original OSDI and DEQ-5 instruments have established validity and reliability [16, 17], and Turkish-language

versions have also been reported [18, 19]. The OSDI score ranges from 0 to 100, with higher scores indicating greater symptom severity; the DEQ-5 evaluates dry eye symptom frequency and intensity.

Clinical evaluations were performed in a standardized sequence to minimize test interference: symptom questionnaires, TMH measurement, meibography, meibomian gland function assessment, ocular surface staining, TBUT, and Schirmer testing. TMH was measured using spectral-domain anterior segment optical coherence tomography (3D OCT-1 Maestro, Topcon, Tokyo, Japan). Measurements were obtained under similar environmental conditions and, whenever possible, at the same time of day. Meibomian gland morphology was evaluated using infrared meibography (Mediworks, Shanghai, China), and gland loss was recorded as a percentage. Meibomian gland function was assessed using meibum quality, expressibility, and lid margin abnormalities. Meibum quality was graded from 0 to 3, ranging from clear secretion to thick, toothpaste-like secretion. Expressibility was scored from 0 to 3 according to the number of expressible glands under standardized pressure, consistent with established MGD assessment principles [14]. Ocular surface epithelial damage was evaluated using fluorescein staining and graded according to the Oxford grading scale. TBUT was measured after fluorescein instillation, and the Schirmer I test was performed without anesthesia.

Definition of symptom–sign phenotypes

Patients were classified into four symptom–sign phenotypes according to symptom severity and objective ocular surface findings: high symptom–high sign, high symptom–low sign, low symptom–high sign, and low symptom–low sign. High symptom status was defined as severe symptoms according to OSDI and/or DEQ-5 criteria. Patients with mild-to-moderate OSDI scores and/or DEQ-5 scores between 6 and 12 were classified as having low symptom burden, whereas patients with severe OSDI scores and/or DEQ-5 scores > 12 were classified as having high symptom burden.

High sign status was defined as the presence of at least two abnormal objective ocular surface parameters among the following: TBUT < 5 seconds, Schirmer I test < 5 mm/5 min, Oxford corneal staining score ≥ 2 , meibomian gland expressibility score ≥ 2 , meibum quality score ≥ 2 , or meibomian gland loss $\geq 35\%$ on meibography. Because several objective ocular surface parameters were used to define sign status, these parameters were not interpreted as independent predictors of symptom–sign discordance; instead, they were analyzed as clinical characteristics associated with predefined symptom–sign phenotypes.

Sample size justification

Because of the retrospective and observational design, all eligible patients who met the inclusion and exclusion criteria during the study period were included. The final sample comprised 120 patients. The primary objective was descriptive estimation of the frequency of symptom–sign discordance; subgroup analyses according to phenotype were considered exploratory and hypothesis-generating. To reduce

overinterpretation, adjusted analyses were limited to clinically relevant covariates. Because age is a known determinant of meibomian gland morphology and function [12], age-adjusted analyses were performed for comparisons of meibomian gland-related parameters across the predefined phenotypes.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation or median with interquartile range, as appropriate, and categorical variables as frequencies and percentages. Normality was assessed using the Shapiro–Wilk test. Spearman correlation analysis evaluated relationships between symptom scores and ocular surface parameters. Comparisons among the four phenotypes used one-way analysis of variance or the Kruskal–Wallis test according to data distribution, with Bonferroni or Dunn–Bonferroni correction for post hoc pairwise comparisons as appropriate. Because age differed significantly among phenotypes and may confound meibomian gland-related parameters, age-adjusted analyses were performed using analysis of covariance or generalized linear models, depending on the distribution and scale of the dependent variable. Adjusted p values were reported for meibomian gland loss, meibum quality score, expressibility score, TBUT, TMH, Oxford staining score, and Schirmer test. Variables included in the objective sign definition were not used as primary independent predictors in regression or Receiver Operating Characteristic (ROC) analyses for discordance, thereby avoiding circular interpretation. A p value < 0.05 was considered statistically significant.

Results

A total of 120 patients were included. Of these, 78 were female (65.0%) and 42 were male (35.0%). Mean age was 48.6 ± 13.2 years. Mean OSDI score was 42.8 ± 18.6 and mean DEQ-5 score was 9.1 ± 4.2 . Mean TBUT was 7.4 ± 3.1 seconds, TMH 0.26 ± 0.08 mm, meibomian gland loss $36.4 \pm 13.7\%$, meibum quality score 1.7 ± 0.8 , expressibility score 1.5 ± 0.8 , Oxford staining score 1.3 ± 0.9 , and Schirmer I value 9.8 ± 5.1 mm/5 min (Table 1).

Table 1
Demographic and Clinical Characteristics of the Study Population

Variable	Value [mean $\pm$ SD, n (%)]
Number of patients	120
Female, n (%)	78 (65.0)
Male, n (%)	42 (35.0)
Age, years	48.6 $\pm$ 13.2
OSDI score	42.8 $\pm$ 18.6
DEQ-5 score	9.1 $\pm$ 4.2
TBUT, s	7.4 $\pm$ 3.1
TMH, mm	0.26 $\pm$ 0.08
Meibography gland loss, %	36.4 $\pm$ 13.7
Meibum quality score	1.7 $\pm$ 0.8
Expressibility score	1.5 $\pm$ 0.8
Oxford staining score	1.3 $\pm$ 0.9
Schirmer test, mm/5 min	9.8 $\pm$ 5.1
OSDI: Ocular Surface Disease Index; DEQ-5: 5-item Dry Eye Questionnaire; TBUT: tear breakup time; TMH: tear meniscus height; SD: standard deviation.	

A moderate negative correlation was observed between OSDI and TBUT ($r = -0.46$, $p < 0.001$), a weak negative correlation between OSDI and TMH ($r = -0.28$, $p = 0.003$), and a weak positive correlation between OSDI and meibography-derived gland loss ($r = 0.39$, $p < 0.001$) (Table 2).

Table 2
Correlation Analysis Between OSDI and Objective Parameters

Parameter	r value*	p value
TBUT	-0.46	< 0.001
TMH	-0.28	0.003
Meibography gland loss	0.39	< 0.001
*Spearman correlation analysis.		

Symptom–sign discordance was identified in 50 patients (41.7%). Twenty-eight patients (23.3%) exhibited a high-symptom/low-sign phenotype and 22 (18.4%) a low-symptom/high-sign phenotype.

Thirty-eight patients (31.7%) were classified as high symptom–high sign and 32 (26.6%) as low symptom–low sign (Table 3).

Table 3
Distribution of Symptom–Sign Phenotypes

Clinical phenotype	n (%)
High symptom – High sign	38 (31.7)
High symptom – Low sign	28 (23.3)
Low symptom – High sign	22 (18.4)
Low symptom – Low sign	32 (26.6)
Total discordance	50 (41.7)

In unadjusted comparisons, the high-symptom/low-sign group showed higher meibum quality and expressibility scores, whereas the low-symptom/high-sign group showed greater meibomian gland loss and was significantly older. After adjustment for age, TBUT ($p = 0.006$), Schirmer I test ($p = 0.018$), Oxford staining score ($p < 0.001$), meibum quality score ($p = 0.011$), and expressibility score ($p = 0.019$) remained significantly different among the four phenotypes. In contrast, the between-group difference in meibomian gland loss was attenuated and no longer statistically significant ($p = 0.071$); TMH remained non-significant ($p = 0.124$) (Table 4). These findings suggest that structural meibomian gland loss in the low-symptom/high-sign phenotype may be partly explained by age, whereas functional meibomian gland impairment remained associated with phenotype after age adjustment.

Table 4
Clinical and Ocular Surface Characteristics According to Symptom–Sign Phenotype

Variable	High symptom– High sign n = 38	High symptom– Low sign n = 28	Low symptom– High sign n = 22	Low symptom– Low sign n = 32	Unadjusted p	Age- adjusted p†
Age, years	47.6 ± 13.1	46.2 ± 12.8	54.3 ± 11.8	44.9 ± 12.4	0.032*	—
Female sex, n (%)	26 (68.4)	18 (64.3)	14 (63.6)	20 (62.5)	0.94	—
OSDI score	55.6 ± 13.8	53.2 ± 12.9	28.4 ± 8.7	25.8 ± 7.9	< 0.001*	< 0.001*
DEQ-5 score	12.8 ± 3.1	12.1 ± 2.9	5.7 ± 1.6	5.4 ± 1.5	< 0.001*	< 0.001*
TBUT, s	5.8 ± 2.4	8.6 ± 2.7	5.3 ± 2.1	9.4 ± 2.6	< 0.001*	0.006*
TMH, mm	0.24 ± 0.07	0.27 ± 0.08	0.23 ± 0.07	0.29 ± 0.08	0.083	0.124
Schirmer test, mm/5 min	7.8 ± 4.4	10.8 ± 4.8	7.1 ± 4.1	12.2 ± 5.3	0.002*	0.018*
Oxford staining score	1.8 ± 0.8	0.8 ± 0.5	1.9 ± 0.7	0.6 ± 0.5	< 0.001*	< 0.001*
Meibomian gland loss, %	35.8 ± 11.6	31.8 ± 10.9	46.2 ± 12.5	29.4 ± 9.8	< 0.001*	0.071
Meibum quality score	1.5 ± 0.6	2.1 ± 0.7	1.4 ± 0.6	1.3 ± 0.5	0.003*	0.011*
Expressibility score	1.3 ± 0.7	1.9 ± 0.8	1.2 ± 0.7	1.1 ± 0.6	0.007*	0.019*
Values are presented as mean ± standard deviation or n (%). OSDI: Ocular Surface Disease Index; DEQ-5: 5-item Dry Eye Questionnaire; TBUT: tear breakup time; TMH: tear meniscus height. †Age-adjusted p values were obtained using analysis of covariance or generalized linear models, as appropriate. *p < 0.05 was considered statistically significant.						

Discussion

The present study demonstrated that symptom–sign discordance is common in patients with DED, with approximately 42% of the cohort showing discordant phenotypes. This finding is consistent with previous studies showing limited agreement between patient-reported symptoms and commonly used objective dry eye signs [5, 6, 20]. The principal contribution of the present study is the characterization of these discordant phenotypes using a multimodal ocular surface assessment while explicitly accounting for age as a potential confounder of meibomian gland-related findings.

In our cohort, OSDI showed only weak-to-moderate correlations with objective parameters. Sullivan et al. similarly reported generally low correlations between dry eye symptoms and individual clinical signs,

while Nichols et al. found no strong association between symptom severity and commonly used dry eye tests [5, 20]. Vehof et al. further demonstrated that symptom–sign discordance is influenced by patient characteristics and systemic factors, including age [6]. Together, these observations support current diagnostic frameworks emphasizing that symptoms and individual objective tests provide complementary rather than interchangeable information [4].

One clinically relevant finding was the high-symptom/low-sign phenotype. These patients had relatively preserved conventional objective signs but worse meibum quality and expressibility scores. MGD is a major contributor to evaporative DED, and functional abnormalities of meibomian secretion can destabilize the tear film even when structural changes are not prominent [7, 8, 14]. Our findings therefore suggest that functional MGD may contribute to symptom generation in a subset of patients whose conventional sign burden appears relatively mild. In clinical practice, substantial symptoms in the presence of limited staining or aqueous deficiency should prompt careful assessment of meibomian gland function rather than reliance on structural imaging alone.

The low-symptom/high-sign phenotype requires a different interpretation. These patients had greater objective abnormalities and higher meibomian gland loss but were also significantly older. Age-related meibomian gland dropout is well documented [12], and epidemiologic data indicate that objective dry eye signs increase with age [21]. Importantly, the between-phenotype difference in gland loss was attenuated after age adjustment and no longer reached statistical significance. This suggests that at least part of the apparent structural gland loss in the low-symptom/high-sign group may reflect age-related change rather than discordance itself, illustrating how unadjusted phenotype comparisons can overestimate the contribution of structural meibomian gland loss.

In contrast, meibum quality and expressibility remained significantly different after age adjustment. Structural gland loss may represent cumulative or age-related damage, whereas secretion quality and expressibility provide information about current gland function [7, 12, 14]. These findings support interpreting structural and functional meibomian gland assessments together. They also accord with the broader concept that evaporative and aqueous-deficient mechanisms frequently overlap in clinical DED rather than forming mutually exclusive categories [22].

DED is heterogeneous, and different mechanisms may contribute to different symptom–sign profiles. Tear film instability, epithelial damage, reduced tear volume, inflammation, MGD, and neurosensory abnormalities can all influence clinical expression [1–4, 8]. Patients with high symptoms and mild signs may have functional MGD or neurosensory amplification; neuropathic ocular pain and altered corneal sensory processing are recognized explanations for disproportionate symptoms in some patients [9–11, 23]. Conversely, patients with low symptoms despite marked signs may have chronic structural change, age-related gland dropout, reduced corneal sensitivity, or sensory adaptation. Because corneal sensitivity and neuropathic pain measurements were unavailable in the present study, these mechanisms remain plausible interpretations rather than directly tested explanations.

From a methodological perspective, variables used to define sign status were not subsequently interpreted as independent predictors of discordance. Using the same objective variables both to construct an outcome and to predict that outcome would risk circular reasoning. The present analysis therefore focused on phenotype characterization and age-adjusted comparisons rather than predictive modeling. This conservative approach improves interpretability but also means that the findings should be regarded as phenotype-descriptive and hypothesis-generating.

This study has limitations. Its retrospective, single-center design may limit generalizability, and the phenotype subgroups were modest in size. Although age-adjusted analyses were performed, residual confounding may remain. Lipid layer interferometry, tear osmolarity, inflammatory biomarkers, corneal sensitivity testing, and dedicated neuropathic pain assessment were unavailable. Finally, the cross-sectional design precludes causal inference. Future prospective studies incorporating neurosensory testing and longitudinal follow-up may clarify whether functional MGD and age-related structural changes identify reproducible discordant DED phenotypes.

Conclusions

Symptom–sign discordance is common in DED and reflects the heterogeneous nature of the disease. Functional meibomian gland impairment may contribute to high symptom burden despite relatively mild conventional signs, whereas structural gland loss in low-symptom/high-sign patients should be interpreted in light of age-related confounding. These findings support a multimodal and age-aware approach to DED assessment incorporating symptom questionnaires, tear film stability, tear volume, ocular surface staining, and both structural and functional meibomian gland evaluation.

Abbreviations

DED: dry eye disease

DEQ-5: dry eye questionnaire-5

MGD: meibomian gland dysfunction

OSDI: ocular surface disease index

ROC: receiver operating characteristic

TBUT: tear breakup time

TMH: tear meniscus height

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Local Ethics Committee of Mersin City Training and Research Hospital (protocol number 25.03.2026-2026/181) and was conducted in accordance with the Declaration of Helsinki. The study was retrospective and involved analysis of routinely collected clinical data. The ethics committee approval did not include a specific statement regarding waiver of informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

ESG and MŞT contributed to conceptualization. FMB and ESG contributed to methodology. MŞT contributed to software. FMB and ESG contributed to validation. MŞT and ESG performed the formal analysis. FMB and ESG contributed to investigation. ESG and MŞT provided resources and curated the data. ESG drafted the manuscript. FMB reviewed and edited the manuscript. MŞT contributed to visualization. ESG supervised and administered the project. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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