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A Review of Current Patterns in Dry Eye Evaluation

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ABSTRACT:

Dry eye disease (DED) is a common, multifactorial ocular surface disorder with wide variability in prevalence, clinical presentation, and underlying pathophysiology across different populations and environments. Previously regarded mainly as a condition of reduced tear production, DED is now understood as a complex disease involving tear film instability, hyperosmolarity, ocular surface inflammation, meibomian gland dysfunction, eyelid and blink abnormalities, and neurosensory alterations, all of which contribute to symptom severity and disease chronicity. Owing to this heterogeneity, no single diagnostic test is adequate for establishing diagnosis or guiding management. This review outlines current patterns in dry eye evaluation, highlighting both conventional and evolving diagnostic modalities. Subjective symptom-based questionnaires such as the Ocular Surface Disease Index, DEQ-5, SPEED, and NEI-VFQ-25 remain essential screening tools but are influenced by patient perception and environmental factors. Objective assessment methods include tear film stability tests (invasive and non-invasive tear break-up time), tear production measurements (Schirmer test and tear meniscus height), ocular surface staining, slit-lamp examination of eyelid and ocular surface abnormalities, and tear composition analysis including osmolarity and inflammatory biomarkers. Each modality evaluates a different component of the lacrimal functional unit, reinforcing the need for a multipronged diagnostic approach. Recent advances such as infrared meibography, non-invasive tear film analyzers, and artificial intelligence–based image analysis have improved diagnostic objectivity, reproducibility, and structural–functional correlation. The TFOS DEWS III (2025) report further refines dry eye evaluation by emphasizing symptom-based diagnosis, simplified objective testing, ocular surface staining, and etiology-based subtyping. Overall, dry eye assessment is transitioning toward a more standardized, data-driven, and personalized model, though challenges related to accessibility, reproducibility, and real-world variability persist.

Introduction

Dry eye disease (DED) is a global health issue with highly variable prevalence rates between countries and even within certain regions of a country [1]. It is a common cause for ophthalmic visits in an eye hospital, with prevalence in India ranging from 18.4% to over 54% [2]. Patients experience difficulties in daily activities that negatively affect vision-related quality of life [3]. The symptoms vary by geographic location, climatic conditions, and lifestyle choices [4]. Dry eye disease has evolved from being considered a lack of tears to being understood as an ocular surface and/or tear film disease of multifactorial aetiology and varied symptomatology. Ocular surface damage and inflammation, Tear film instability and hyperosmolarity, and neuro-sensory abnormalities have been evidenced to have an effect [5].

The multifactorial etiology of dry eye disease – namely, tear-film deficiency of aqueous/lipid/mucin components, eyelid/blink abnormalities, meibomian gland dysfunction (MGD), ocular surface damage and/or inflammation, neurosensory dysfunction – no single test can be considered sufficient for adequate diagnosis and treatment strategy formulation. A combination of tests for symptom evaluation, objective testing, and assessment is necessary, utilizing a multipronged subtype-guided approach, as recommended by the new DEWS III guidelines [5]. Traditional and Established Methods for Dry Eye Evaluation can broadly be divided into Objective and Subjective methods.

Subjective Methods

Symptom Questionnaires

The 12-item Ocular Surface Disease Index (OSDI) or the Dry Eye Questionnaire-5 (DEQ-5) are commonly used questionnaires in the outpatient department, which capture patient-reported symptoms (dryness, burning, visual disturbance, and quality of life) [6]. SPEED Questionnaire (Standardized Patient Eye Experience Survey): It assesses the frequency and severity of dry eye-related symptoms (dryness, grittiness, burning, watering, fatigue) and grades them based on their impact into mild, moderate, or severe DED. NEI-VFQ-25 (National Eye Institute Visual Function Questionnaire): Includes questions about eye irritation and its effect on quality of life, yielding a score from 0 (worst) to 100 (best). Such questionnaires are screening methods and suggest further evaluation. They are, however, subjective and influenced by the patient's personal perception, recall, mood, environment, and other factors.

Objective Tests

Tear Film Stability Tests

Tear Break-Up Time (TBUT) – done with Sodium fluorescein strips. The time from blink to the first dry spot is measured, with values less than 10 seconds considered abnormal [7]. De-merits – Sodium Fluorescein is known to destabilize the tear film and cause lowered results, additionally causing irritation too. Inter-observer variability is a known issue, reducing the reproducibility of results [8]. NIBUT – Non-invasive TBUT using dedicated tear film analyzers or newer-generation corneal topographers is increasingly recommended [8].

Tests of Tear Production

Schirmer Test

A Whatman 41 filter paper is placed in the lower fornix for 5 minutes, and the extent of wetting is noted—values less than 15mm are considered abnormal. Done without local anaesthetic (Schirmer 1), it is a measure of the basal+reflex tear production, whereas with local anaesthesia (Schirmer 2), the basal secretion is measured [9]. The Schirmer test is unfortunately plagued by poor reproducibility, inter- and intra-individual variability, patient discomfort, reflex tearing or evaporation bias, and a lack of consensus regarding normal values. Tear Meniscus Height – It is a proxy for existing tear volume on the surface of the eye, which can be assessed visually or via imaging modalities (Slit lamp examination, meibography devices, Anterior Segment OCT) [10].

Tests of Ocular Surface Conditions

Dye staining and examination under a slit lamp are used to detect punctate epithelial erosions, devitalized cells, lid-margin epitheliopathy, and other conditions. Common dyes used are Sodium Fluorescein for the cornea, and Lissamine Green / Rose Bengal for the conjunctiva and lid margin [11].

Slit lamp examination - MGD or eyelid/blink-related dry eye requires examination of blink completeness and rate, eyelid margin, meibomian gland orifices, ocular surface abnormalities – all done on slit lamp.

Tests of Tear Composition

Tear osmolarity: hyperosmolarity is a hallmark of unstable tear film and DED; it is widely considered to be a reproducible metric correlating well with disease severity [9].

Tear biomarkers (e.g., inflammatory markers such as matrix metalloproteinase-9 / MMP-9) have been used to detect surface inflammation, although they are not yet universally adopted in all settings [12]. As none of the tests alone can determine the complete treatment protocol, a mix of the above tests is used, as each method covers a different aspect of tear-film / ocular-surface health.

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S No	Country	Author	Year	Samples	Type of study	Outcome	Refer-ences
1	Spain	Garaszczuk et al.	2018	50	Cross sectional	OCT-based Tear Cell Receptor can be used as an additional measure of the lacrimal functional unit.	[13]
2	Saudi Arabia	Yasir et al.	2019	890	Cross sectional	The country has a high prevalence of DED with significant association noted with female gender, glaucoma, and topical glaucoma medications.	
3	China	Gu et al.	2020	148	Cross-sectional	Usage of Contact lenses may lead to a higher MG dropout rate, which in turn influences tear film status.	
4	UK	Pult et al.	2021 / 2022	24	Cross sectional	The NIBUT and TMH of Visionix 120+ differed markedly from standard methods; low agreement (Kappa, ICC), and poor predictive value (ROC)	[14]
5	India	Singh et al.	2022	474	Cross sectional	In a normal Indian population, TMH is weakly affected by age and is independent of sex, NIBUT, and tear osmolarity. Tear break-up time and osmolarity show no significant variation related to age or sex.	[15]
6	China	Gong et al	2022	78	Prospective observational study	Pre-operative Grade of MG loss had a significant effect on dry eye discomfort symptoms postoperatively. Dry eye was initially associated with vision-related discomfort and later with environmental factors.	[16]
7	Spain	Silva-Viguera et al	2022 / 2023	88	Cross sectional	Diabetic patients (even those without retinopathy) exhibited altered tear-film layers and MGL, indicating that chronic systemic disease (diabetes) influences the ocular surface, supporting the inclusion of systemic conditions when evaluating DED.	
8	Turkey	Yesilkaya et al	2023	80	Cross sectional	Found significant decrease in Schirmer I, invasive TBUT, NI-TBT at 1 week and 1 month post-op; non-invasive parameters detected tear-film instability earlier than standard tests — showing newer devices may better capture post-surgical dry-eye risk.	[17]

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9	India	Fatima et al	2023	150	Cross sectional	Even in "preclinical" (symptomatic but without overt signs) dry eye, tear film abnormalities and subclinical MG morphological changes were detected, supporting the early detection of disease using combined functional and structural metrics.	
10	Spain	Pena-Verdeal et al	2023	260	Cross sectional	The inter-eye TMH difference is a valuable marker: in many aqueous-deficient DED patients, significant asymmetry exists, suggesting that the TMH inter-eye difference could assist in diagnosis beyond absolute cutoff values.	[18]
11	Egypt	Saif et al	2024	400	Cross sectional	High prevalence of tear-film instability, reduced TMH, reduced Schirmer in long-term computer users with symptoms — underlines the role of environmental/behavioral factors in dry eye and the value of multiple diagnostic tests.	
12	China	He et al	2025	300	Cross sectional	Demonstrated significant postoperative decline in tear-film stability and tear production, and increased dry-eye symptoms — reinforcing the need for careful ocular surface evaluation in surgical populations.	[19]

Dry Eye Evaluation - Updates and Advances

Advancements in technology and new evidence have introduced new methods of diagnosis and treatment protocols for Dry Eye Disease. Key advances include:

Quantitative and Qualitative Gland Imaging

Infrared meibography - allows visualization of meibomian gland structure (morphological changes, gland dropout, atrophy) — critical for diagnosing MGD / evaporative dry eye [20].

It gives structural information about the gland that functional tests (like TBUT or Schirmer) cannot provide. Combined information about the structure (meibomian glands) and function (tear film, blink, lipid layer) provides a more complete picture [21].

Deep-learning (AI)–based segmentation interpretation of meibomian glands provides quantitative, reproducible measures (gland area, dropout ratio, meiboscore) and can also correct for artifacts such as specular reflections. This improves repeatability and reduces observer bias, which is important in standardizing MGD assessment [22].

Automated / AI-based Analysis

A recent smartphone-based deep learning algorithm has been developed and validated for the automatic detection and measurement of TMH, utilizing images from devices such as the Keratograph 5M. This may help make tear-volume assessment more accessible and less operator-dependent [23]. With increasing smartphone penetration and the rise of portable devices, such automated TMH measurement could democratize dry-eye screening, especially in resource-limited settings. On tear-film stability: a very recent development (2025) is the creation of an annotated dataset and automated pipeline

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(e.g., **tfm-net / TF-Collab)** for **automated tear film break-up (TFBU)** segmentation from video, potentially enabling real-time, objective, reproducible measurement of tear break-up dynamics instead of subjective, observer-based TBUT [22].

Similarly, new work using vision-transformer-based deep learning can infer thin-liquid–film thickness profiles from interferometry patterns (e.g., lipid or aqueous tear layers), which could in the future provide continuous, non-invasive tear film thickness monitoring — a significant leap toward dynamic, functional tear-film assessment [24]. Integrated / Multimodal Diagnostic Pipelines and AI Decision Support Emerging proposals suggest combining image-based data (meibography, tear meniscus, tear-film break-up videos), clinical metadata (symptoms, blink rate, lid health, ocular history), and then utilizing machine learning / LLM-based systems to output diagnostic suggestions, subtype classification, and management guidance [23]. This approach aims to reduce subjectivity, improve reproducibility, and make dry eye evaluation more holistic and data-driven — particularly helpful in complex or mixed-driver DED.

What the DEWS III (2025) Report Changes

The newly published DEWS III consensus (2025) marks a significant shift in how clinicians are advised to approach dry eye diagnosis and classification. Key updates include:

1. DED is now firmly defined as a symptomatic disease — i.e., presence of ocular symptoms is mandatory for the diagnosis [5].

2. DEWS III expands the classification beyond the older dichotomy (aqueous-deficient vs evaporative) to an etiology-based subtyping**.**

The new subtypes include: Tear-film deficiencies (aqueous, lipid, mucin), Eyelid/blink abnormalities (lid margin, blink quality, closure), Meibomian gland dysfunction, Ocular surface abnormalities (e.g., anatomical, neural dysfunction, surface inflammation, oxidative stress), Mixed-etiology cases. This reorientation acknowledges that many patients have multiple overlapping drivers**,** underscoring the need for a combination therapy approach [3].

3. A streamlined, Evidence-based Diagnostic Algorithm DEWS III recommends a three-step core diagnostic algorithm [5]**:** Symptom screening using a new, shorter questionnaire: OSDI-6 (score ≥ 4 indicates potential dry eye) rather than the full 12-item OSDI or DEQ-5.

Objective test — Either non-invasive tear break-up time (NIBUT) with a cut-off of less than 10 or tear-film osmolarity (≥ 308 mOsm/L in either eye or an interocular difference of less than 8 mOsm/L).

Ocular surface staining (after objective test): if present, defined as more than 5 spots of corneal punctate staining**,** or more than 9 spots of conjunctival punctate staining**,** or lid-margin changes (lissamine green) ≥ 2 mm length and ≥ 25% width. A positive result in the algorithm supports a diagnosis of DED; further subtype-specific tests (lid/blink assessment, meibography, lipid-layer analysis, inflammatory markers) can then guide tailored management.

Implications for Clinical Practice

The new algorithm emphasizes simplicity, reproducibility, and accessibility**:** a short questionnaire, a single objective test, and staining. It also lowers the barrier for general eye care practitioners and may increase detection, especially in primary or low-resource settings. Etiological subtyping enables personalized treatment**,** improving patient outcomes and quality of life [5].

Challenges even with DEWS III

Despite the advances, dry eye evaluation remains imperfect. Some of the main challenges: Variability & Reproducibility

Many traditional tests — especially the Schirmer test — have poor reproducibility and can be affected by environmental factors, reflex tearing, evaporation, patient discomfort, and other variables [25]. Even advanced imaging-based methods require expertise; for example, the interpretation of meibography can vary. Although AI-based segmentation helps, these methods are still being optimized and may not yet be universally available.

Standardization across devices and centers: Even with AI tools, variations in imaging devices, lighting conditions, user technique, and environmental factors (such as humidity, blink rate, and screen time) may influence measurements. A consensus on instrumentation, calibration, and normative data across different populations is still pending.

Dynamic, real-world DED fluctuations: Tear film parameters can vary significantly depending on environmental factors, blink patterns, time of day, and humidity — so a single clinic visit may not accurately reflect the full picture. Hence, repeated monitoring might be needed.

Access: Advanced diagnostics (non-invasive tear-film analyzers, meibography, osmolarity meters, and AI tools) remain unavailable in many parts of the world — especially in low-resource settings. Bridging this gap will require cost-effective, portable, standardized tools.

Mixed / Overlapping Pathologies — Complexity in Interpretation

Many patients have mixed-driver DED (e.g., both lipid deficiency due to MGD *and* reduced aqueous production). Subtyping helps guide therapy, but in practice, overlapping signs may make it difficult to assign a dominant driver. Some DED patients have prominent neurosensory dysfunction (pain or discomfort out of proportion to observable surface changes), or fluctuating symptoms — these may be under-recognized even by advanced algorithms, because objective measures often lag behind subjective experience. DEWS III acknowledge the role of neurosensory abnormalities, but diagnostic measures for them remain limited. Under-recognized contributors include neurosensory dysfunction, inflammation, the mucin layer, the ocular surface microbiome, and Demodex — many of these are still challenging to measure reliably. Although DEWS III includes them among possible drivers, more validated and accessible tests are needed.

Translating new diagnostics into better outcomes: Even with improved subtype-based diagnosis, the evidence base for some interventions (especially newer ones) remains limited. Long-term, real-world studies are needed to demonstrate that precision diagnosis and tailored therapy translate into improved patient-reported outcomes, quality of life, and ocular health.

Conclusion

The landscape of dry eye disease evaluation is undergoing a significant transformation**.** The recent DEWS III consensus (2025) reflects decades of growing understanding: dry eye is not just “not enough tears,” but a complex, multifactorial ocular surface disease**.** By combining symptom-based screening, objective testing, ocular-surface staining, and etiology-based subclassification**,** clinicians are now better equipped to diagnose DED accurately and, just as importantly, tailor therapy to the underlying cause(s) for each patient. Complementing this paradigm shift, technological advances — especially imaging, deep learning, automated tear-film analysis, and AI-assisted decision tools — promise to make diagnosis more objective, reproducible, and accessible. With time, these tools may help transform DED care: from a "trial-and-error" use of lubricants to mechanism-driven, precision ocular-surface medicine**.** That said, significant challenges remain, including accessibility, standardization, cost, variable patient presentations, dynamic tear-film fluctuations, and the need for stronger outcome data. The next few years, as new diagnostics and therapies are tested and deployed, will be critical.

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