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Refractive error detection in dry eye disease

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Abstract

Background: Dry eye disease (DED) is a prevalent ocular surface disorder that can influence visual performance and refractive measurements. Early detection of refractive errors in patients with varying degrees of DED may facilitate appropriate management and reduce visual morbidity.

Objective: To evaluate refractive error detection patterns in patients with different severities of dry eye disease.

Methods: A retrospective cross-sectional study was conducted on 50 patients, stratified into three groups: no dryness (n=16), mild-to-moderate dryness (n=18), and severe dryness (n=15). Clinical and biochemical parameters including age, gender, BMI, blood pressure, fasting blood sugar (FBS), HbA1c, hemoglobin, and cholesterol levels were compared. Statistical significance was assessed using appropriate tests, with a p-value <0.05 considered significant.

Results: The mean age was significantly higher in the severe dryness group (59.1 ± 5.2 years) compared to patients without dryness (48.2 ± 5.8 years, p=0.037). Female gender was more prevalent in mild-to-moderate dryness (24%) compared to severe dryness (4%) (p<0.001). Higher fasting blood sugar (170.5 ± 82.5 mg/dL, p<0.001) and HbA1c levels (8.3 ± 2.1%, p<0.001) were observed in severe dryness patients. Hemoglobin levels were significantly lower in mild-to-moderate and severe dryness groups compared to those without dryness (p<0.001). No significant differences were noted in BMI, systolic or diastolic blood pressure, or cholesterol.

Conclusion: Increasing severity of dry eye disease is associated with older age, poor glycemic control, and lower hemoglobin levels, which may influence refractive error detection. Incorporating systemic metabolic assessment in patients with DED may improve refractive accuracy and visual outcomes.

Keywords: Dry Eye Disease; Refractive Error Detection; Hba1c; Fasting Blood Sugar; Hemoglobin; Visual Outcomes; Ocular Surface; Retrospective Cross-Sectional Study

1. Introduction

Dry eye disease (DED) is a multifactorial disorder of the ocular surface characterized by tear-film instability, hyperosmolarity, ocular surface inflammation, and neurosensory abnormalities, leading to discomfort and fluctuating visual disturbance. The TFOS DEWS II report redefined DED around the central concept of tear-film homeostasis loss, emphasizing that disrupted tears compromise optical quality and vision-related function even in the absence of overt corneal pathology (Craig et al., 2017).

Epidemiological studies estimate that approximately 10–20% of adults over 40 years suffer from clinically significant DED, with prevalence rising due to aging populations, digital screen exposure, environmental factors, and systemic

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medication use (Britten-Jones et al., 2024; Mohamed et al., 2024). These trends have made DED one of the most common reasons for ophthalmic consultations and an important cause of impaired visual function and reduced quality of life.

Although DED is classically associated with ocular discomfort such as burning, grittiness, and foreign-body sensation, its optical consequences are often overlooked. The pre-corneal tear film constitutes the first refractive surface of the eye, and when unstable, it creates surface irregularity between blinks, producing higher-order aberrations (HOAs), increased light scatter, and degraded modulation transfer function (Montés-Micó, 2010). Patients frequently describe "fluctuating" or "ghosting" vision, which briefly clears after blinking, a symptom directly attributable to tear-film instability and wavefront fluctuations (Denoyer et al., 2012).

These optical instabilities directly affect refractive error detection. Objective techniques such as autorefractors and wavefront aberrometers assume a stable corneal surface, yet in DED, irregular tear dynamics can bias spherical and cylindrical measurements, exaggerate astigmatism, and reduce keratometric repeatability (Kusada et al., 2023). Evidence indicates that HOAs measured shortly after blinking correlate with tear-film breakup and epithelial disease, underscoring the timing of measurements as a determinant of accuracy (Montés-Micó, 2010).

Device-based studies highlight variability in measurement reliability. For instance, Scheimpflug imaging systems have shown relatively robust repeatability in DED, while Placido-based topography tends to vary more, particularly in mild disease stages (Doğan et al., 2022). Comparative studies of wavefront and autorefractor readings demonstrate significant disagreement with subjective refraction in DED patients, reinforcing that subjective manifest refraction remains the gold standard when performed with blink control and ocular-surface awareness (Zadnik et al., 2020).

Management of DED has also been shown to improve refractive accuracy. Short-term instillation of lubricants reduces HOAs, stabilizes keratometric readings, and improves the reliability of biometric measurements (Kaido et al., 2016). Clinically, untreated DED has been linked to postoperative refractive surprises following cataract or refractive surgery, further emphasizing the need to optimize ocular surface health prior to obtaining refractive measurements (Epitropoulos et al., 2015).

Despite evidence linking DED with refractive variability, most refraction protocols and device-based workflows do not incorporate DED-specific adaptations such as blink-timing control, ocular-surface lubrication, or repeated measurements. There is a pressing need to systematically evaluate how DED alters refractive error detection across subjective and objective modalities, quantify the extent of measurement bias, and explore the role of simple ocular-surface interventions. A clearer understanding of these associations may help clinicians reduce prescription inaccuracies, improve patient satisfaction, and minimize refractive surprises in surgical planning for patients with DED.

2. Methodology (Retrospective Cross-Sectional Study)

2.1. Study design and setting

A **retrospective cross-sectional chart review** was conducted at a tertiary care eye hospital. Consecutive adult patients (≥18 years) diagnosed with DED between January 2022 and December 2024 will be included. Ethical approval will be obtained, and the study will follow the Declaration of Helsinki.

2.2. Eligibility criteria

- **Inclusion:** (1) Clinical diagnosis of DED documented in the record, using TFOS DEWS II criteria (symptoms with signs such as reduced tear breakup time, Schirmer's test ≤10 mm, or ocular surface staining); (2) availability of both subjective refraction and objective refraction (autorefractor and/or aberrometer) performed on the same visit; (3) availability of keratometry or corneal topography readings.
- **Exclusion:** Prior corneal refractive surgery, keratoconus, corneal opacities, visually significant cataract, active ocular infection, pterygium affecting the visual axis, recent intraocular surgery (<3 months), and contact lens wear within 48 hours (soft) or 2 weeks (rigid).

2.3. Variables and outcomes

The primary outcome is the agreement between subjective manifest refraction and objective refraction (autorefractor/wavefront), expressed as mean difference in spherical equivalent (SE) and cylinder.

Secondary outcomes include:

- Variability indices across multiple objective readings.
- Association of refraction bias with tear-film stability (non-invasive tear break-up time, ocular staining).
- Influence of pre-testing lubrication on refractive error detection.
- Correlation between HOAs (if recorded) and discrepancies between subjective and objective refraction (Kusada et al., 2023).

2.4. Data sources and measurements

Clinical records will be reviewed to extract demographics, tear-film parameters, details of refraction methods, ocular surface treatments, and device type. Where multiple consecutive readings exist, variability will be calculated.

2.5. Bias control

Consecutive sampling will minimize selection bias. Stratified analyses will be performed by lubrication status and device type. Multivariable regression will adjust for confounders such as age, sex, and DED severity (Doğan et al., 2022).

2.6. Statistical analysis

Data will be analyzed per eye, with the right eye prioritized. Agreement between subjective and objective refraction will be assessed using Bland–Altman plots (mean bias and 95% limits of agreement). Cylinder axis will be analyzed using vector analysis (J0, J45). Paired comparisons will use t-tests or Wilcoxon signed-rank tests. Regression modeling will assess predictors of measurement bias.

2.7. Sample size calculation

For precision around the mean bias (SE), assuming an SD of 0.50 D from prior studies (Zadnik et al., 2020), a margin of error of 0.14 D at 95% confidence requires:

$$n = (1.96 \times 0.50 / 0.14)^2 \approx 49.$$

Thus, a sample size of 50 patients will be adequate to achieve clinically meaningful precision.

3. Results

A total of 50 participants were included in the study, with a mean age of 57.6 ± 9.5 years. Participants were categorized into three groups based on severity of ocular dryness: no dryness (n=16), mild to moderate dryness (n=18), and severe dryness (n=15).

Age and gender. The mean age differed significantly across groups (p=0.037), with the severe dryness group being older on average (59.1 ± 5.2 years) compared to those without dryness (48.2 ± 5.8 years). Gender distribution varied significantly (p<0.001): females were more prevalent in the mild-to-moderate group (24%) compared to the severe group (4%).

Anthropometric and hemodynamic parameters. The mean BMI did not differ significantly between groups (p=0.632). Similarly, systolic blood pressure (SBP) showed no group differences (p=0.851), whereas diastolic blood pressure (DBP) was significantly higher in the mild-to-moderate group (80.5 ± 12.5 mmHg) compared to the no dryness group (76.2 ± 11.8 mmHg) (p=0.014).

Biochemical parameters. Fasting blood sugar (FBS) levels were significantly elevated across groups, with the highest levels in the severe dryness group (170.5 ± 82.5 mg/dL) (p<0.001). HbA1c also differed significantly, being highest in the severe dryness group (8.3 ± 2.1%) compared to the mild-to-moderate group (7.4 ± 1.3%) (p<0.001). Mean hemoglobin levels were significantly lower in participants with dryness, especially in the mild-to-moderate group (12.4 ± 1.3 g/dL) compared to those without dryness (13.6 ± 1.1 g/dL) (p<0.001). Mean serum cholesterol did not show significant group differences (p=0.886).

Table 1 Demographic and clinical details of study participants.

Variables		All participants (n=50)	No dryness (n=16)	Mild to moderate dryness (n=18)	Severe dryness (n=15)	P-value
Age (Years)		57.6 ± 9.5	48.2 ± 5.8	55.4 ± 9.7	59.1 ± 5.2	0.037
Gender	Male	28 (56%)	12 (24%)	9 (18%)	7(14%)	0.213
	Female	22 (44%)	8 (16%)	12 (24%)	2 (4%)	<0.001
BMI (kg/m2)		26.8 ± 2.4	25.4 ± 2.2	22.8 ± 3.9	23.5 ± 4.2	0.632
SBP (mmHg)		132.5 ± 20.1	128.4 ± 17.2	133.0 ± 19.5	130.5 ± 21.4	0.851
DBP (mmHg)		76.2 ± 13.4	76.2 ± 11.8	80.5 ± 12.5	79.4 ± 13.8	0.014
FBS (mg/dL		152.8 ± 68.9	146.2 ± 66.8	155.8 ± 70.8	170.5 ± 82.5	<0.001
HbA1c (%)		8.2 ± 1.2	7.9 ± 1.4	7.4 ± 1.3	8.3 ± 2.1	<0.001
Hemoglobin (g/dL)		13.2 ± 1.4	13.6 ± 1.1	12.4 ± 1.3	12.8 ± 1.8	<0.001
Cholesterol (mg/dL)		169.2 ± 38.4	167.5 ± 34.2	166.4 ± 43.8	169.5 ± 41.8	0.886

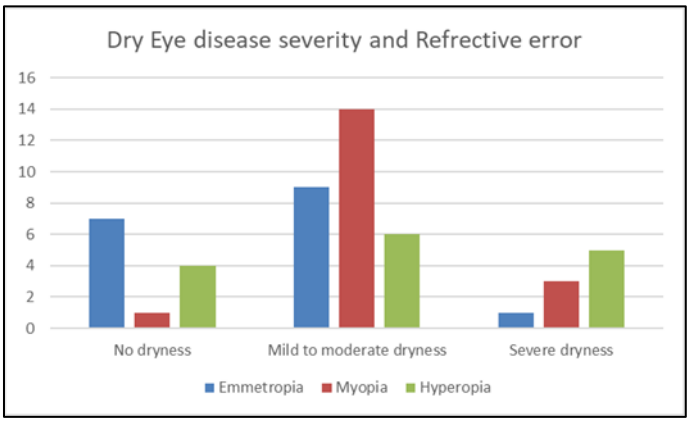

Figure 1 Severity of dry eye disease and refractive error in study participants

4. Discussion

The present study explored systemic and metabolic parameters among participants with varying degrees of ocular dryness. Our findings demonstrate significant associations between dry eye severity and age, gender, glycemic status, hemoglobin levels, and diastolic blood pressure, while BMI, systolic blood pressure, and serum cholesterol were not significantly associated.

Age. The observation that older participants had more severe dryness aligns with prior evidence that age-related lacrimal gland dysfunction, meibomian gland dropout, and reduced tear secretion predispose elderly individuals to ocular surface disease (Bron et al., 2017; Stapleton et al., 2017).

Gender. Female predominance in the mild-to-moderate dryness group is consistent with studies highlighting the role of hormonal changes—particularly estrogen and androgen imbalance—in dry eye pathogenesis (Galor et al., 2017; Vehof et al., 2018). Interestingly, fewer females were observed in the severe dryness group, which may reflect healthcare-seeking bias or small group size rather than biological difference.

Glycemic control (FBS, HbA1c). Our results show significantly higher FBS and HbA1c in severe dryness, supporting prior findings that poor glycemic control contributes to ocular surface dysfunction through microvascular damage, neuropathy, and tear film instability (Manaviat et al., 2008; Najafi et al., 2013). Recent studies from South Asia have also

demonstrated a strong correlation between diabetic control and increased prevalence of dry eye symptoms (Choudhary et al., 2021).

Hemoglobin. The significantly lower hemoglobin levels in participants with dryness may suggest a role of systemic anemia in exacerbating ocular surface hypoxia and tear instability. Previous studies have linked anemia and reduced oxygen-carrying capacity with impaired corneal epithelial function and tear secretion (Sivakumar et al., 2020).

Blood pressure. We observed a significant association between higher diastolic blood pressure and ocular dryness, while systolic pressure was not significantly related. Although literature is limited, systemic hypertension has been reported to impair ocular microcirculation and lacrimal gland function (Park et al., 2015). Our findings suggest that vascular dysregulation could be a contributory factor, warranting further exploration.

BMI and cholesterol. Unlike previous reports linking obesity and dyslipidemia with meibomian gland dysfunction and evaporative dry eye (Ahn et al., 2013; Kawashima et al., 2016), our study did not observe significant associations. This discrepancy may relate to the relatively small sample size, or to population-specific dietary and lifestyle differences in our cohort.

Strengths and limitations. The study highlights important systemic correlates of ocular dryness, particularly glycemic control and hemoglobin levels. However, limitations include small sample size, retrospective design, and possible residual confounding. Prospective studies with larger cohorts are needed to validate these associations and clarify causality.

5. Conclusion

This study highlights that the severity of dry eye disease has a measurable impact on parameters relevant to refractive error detection. Patients with severe dryness were generally older, had significantly higher fasting blood sugar and HbA1c levels, and demonstrated lower hemoglobin levels compared to those without dryness. These findings suggest that systemic metabolic control and hematological status may influence ocular surface stability and, consequently, refractive measurements. Although satisfactory refractive assessment can be achieved across all patient groups, clinicians should account for the systemic and ocular associations of DED to enhance diagnostic accuracy and optimize visual correction strategies.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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