Cross-sectional Study Exploring Vision-related Quality of Life in Dry Eye Disease in a Norwegian Optometric Practice

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SIGNIFICANCE: Dry eye disease causes ocular pain, blurred vision, reduced visual quality of life, and reduced workplace performance. This disease is underreported and underdiagnosed despite being highly prevalent in optometric care.

PURPOSE: This study aimed to explore the vision-related quality of life of patients with dry eye disease and the potential benefits of screening for dry eye disease in Norwegian optometric practice.

METHODS: This study adopted an observational, prospective, cross-sectional design. All patients between 18 and 70 years of age who were examined between June 8 and July 5, 2018, at Erøy Optikk, Kristiansand, Norway, were invited to participate. Dry eye disease was assessed according to Tear Film & Ocular Surface Society International Dry Eye Workshop II report recommendations. Vision-related quality of life was assessed with the National Eye Institute 25-item Visual Function Questionnaire.

RESULTS: Forty-nine patients participated in the study; 29 (59%) were female, and 29 (59%) had dry eye disease. The patients with dry eye disease reported significantly more ocular pain and (vision-specific) role difficulties than the patients without dry eye disease. After adjusting for age, sex, and habitual visual acuity, dry eye disease was found to be an independent predictor of both ocular pain ($r^2 = 0.328$, $P = .001$) and (vision-specific) role difficulties ($r^2 = 0.240$, $P = .02$). Both habitual visual acuity and dry eye disease were predictors of reduced general vision, a reduced score for near activity and reduced (vision-specific) mental health.

CONCLUSIONS: Dry eye disease was an independent predictor of ocular pain (vision-specific), role difficulties, and reduced general vision, near vision, and (vision-specific) mental health. Optometrists should consider dry eye disease as a cause of reduced vision and quality of vision. Furthermore, we propose that screening for dry eye disease in Norwegian optometric practice can promote better vision and health among patients.

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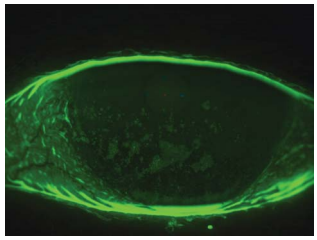

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Dry eye disease often causes patients to seek medical care.[1] The reported prevalence of dry eye disease in the general population varies from 5 to 50%[1] and increases as the population ages.[2] The heterogeneity of dry eye disease and the lack of correlation between its signs and symptoms have led to this disease being underreported and underdiagnosed.[3] Studies have found that the vision problems associated with dry eye disease can lead to mental health issues, such as depression and anxiety, and reduced quality of life.[1,4] Dry eye disease also reduces performance at work[5] and in daily life.[6] A Norwegian study found that 46% of patients attending Norwegian optometric practice had a dry eye disease.[7] Dry eye disease is mostly managed with patient education, warm compresses, and artificial tears; however, more severe cases may warrant pharmaceutical approaches, such as corticosteroids and secretagogues, ointments, punctal occlusion, and in-office treatments.[8] In Scandinavian countries, little research has been conducted on the impact of dry eye disease on vision-related quality of life.[9] Norway is one of the countries with the highest number of smartphone users in the world.[10] Furthermore, because of its cold climate, people spend a substantial proportion of their time under low-humidity conditions, in electrically heated houses and offices, which can contribute to dry eye disease.[1] This study aimed to explore the vision-related quality of life of patients with dry eye disease and the potential benefits of screening for dry eye disease in Norwegian optometric practice.

METHODS

This study adopted an observational, prospective, cross-sectional design exploring dry eye disease and vision-related quality of life among patients examined in a Norwegian optometric practice using validated questionnaires and standardized clinical tests. The hypothesis was that dry eye disease affects the general and specific aspects of vision as well as the quality of life of the patients.

The study population included patients examined in an optometric practice in Kristiansand, Norway. All patients between 18 and 70 years of age who had attended the routine eye examinations at Erøy Optikk, Kristiansand, Norway, were invited to participate in the study. Both patients with and without dry eye symptoms were

eligible to participate. The study sample consists of the 49 patients who accepted the invitation, which comprised 69% of all patients who attended the routine eye examinations between June 8 and July 5, 2018.

A priori sample size calculation estimated a total sample size of 40 patients: 20 patients with dry eye disease and 20 patients without dry eye disease. The sample size was estimated using the Sampsize calculator (epiGenysis, University of Sheffield, Sheffield, UK), which detected a mean score difference of 14 for general vision on the National Eye Institute 25-item Visual Function Questionnaire[11] between patients with dry eye symptoms (69 ± 12)[12] and patients without dry eye symptoms (83 ± 12),[11] with a precision (α) of 5% and a power of 90%.

The data collection occurred between June 8 and July 5, 2018. The participants were instructed not to wear contact lenses or eye makeup to the examination. First, the participants filled out two self-report questionnaires related to ocular symptoms and vision-related quality of life: the National Eye Institute 25-item Visual Function Questionnaire[11] and the Ocular Surface Disease Index (OSDI).[13] After this, they underwent a dry eye examination according to the recommendations of the Tear Film & Ocular Surface Society International Dry Eye Workshop II report.[14] The patients took 5 to 15 minutes to fill out the questionnaires. The National Eye Institute 25-item Visual Function Questionnaire is a non–disease-specific, visual quality-of-life questionnaire developed to measure self-reported vision-related health status, particularly in patients with chronic eye diseases. This questionnaire was designed to measure the level of severity of visual symptoms or difficulty of activities based on 12 generic health domains[11]: general health, general vision, ocular pain, near activities, distance activities, vision-specific social functioning, vision-specific mental health, vision-specific role difficulties, vision-specific dependency, driving, color vision, and peripheral vision (Appendix Table A1, available at http://links.lww.com/OPX/A691). This questionnaire has been used in several clinical studies investigating various chronic ocular conditions; furthermore, it has been validated and translated into Norwegian.[15] Despite the nonspecific nature of this questionnaire, it was chosen to explore the impact of dry eye disease on vision-related quality of life compared with other chronic eye diseases.

The OSDI is a validated, 12-item, disease-specific questionnaire that was developed to measure ocular irritation and its effect on vision-related function.[13] It has been used in several dry eye studies and has also been translated into Norwegian. The total OSDI score has been calculated according to the OSDI manual.[13] This questionnaire has been recommended by the Tear Film & Ocular Surface Society International Dry Eye Workshop II report as a reliable tool for diagnosing dry eye disease.[14] In this study, the OSDI was chosen to facilitate a comparison with the results of similar studies, including those published by the Norwegian Dry Eye Clinic, Oslo, Norway.

The dry eye assessment was performed according to the recommendations of the Tear Film & Ocular Surface Society International Dry Eye Workshop II report; the tests presumed to be the least invasive were performed first.[14] We examined both eyes, and the order of testing was as follows: self-report questionnaires, tear osmolarity, habitual visual acuity, best-corrected visual acuity, tear meniscus height, noninvasive keratography breakup time, ocular surface staining, and meibomian gland assessment. The choice of assessing tear osmolarity before noninvasive keratography breakup time assumed that the I-PEN Tear Osmolarity System (I-Med PHARMA, Saint-Laurent, Quebec, Canada) is less invasive than the TearLab test described in the Tear Film & Ocular Surface Society International Dry Eye Workshop II diagnostic methodology report. To conduct a TearLab osmolarity test, tears are extracted from the ocular surface, whereas the I-PEN reads the tear osmolarity instantly when the test chip is gently placed toward the bulbus oculi in the inferior fornix.

The logarithm of the minimum angle of resolution habitual visual acuity and best-corrected visual acuity were measured with an Early Treatment of Diabetic Retinopathy Study chart displayed on a Topcon CC 100 XP digital LED LCD screen (Topcon Healthcare, Capelle aan den Ijssel, the Netherlands), registered with one decimal place on a continuous scale. The viewing distance was set to 3.80 m, and the size of the letters was calibrated according to the manufacturer's instructions. The visual acuity score was noted according to the logarithm of the minimum angle of resolution formula: logarithm of the minimum angle of resolution = baseline acuity + (0.02 $\times$ the number of missed letters or letters not read). Baseline visual acuity was defined as the lowest line that the patient could read with at least one letter seen correctly.[16] The habitual visual acuity and best-corrected visual acuity were measured for the right and left eyes, as well as binocularly. Tear osmolarity was measured with the I-PEN Tear Osmolarity System (I-Med PHARMA). An osmolarity ≥308 mOsm/L in either eye or an interocular difference >8 mOsm/L was defined as a positive (homeostasis) marker for dry eye.[14] The tear meniscus height was measured with an OCULUS Keratograph 5M (Wetzlar, Germany) and used to guide the subclassification of dry eye disease.[14] A tear meniscus height <0.2 mm was considered a positive finding of an aqueous deficient dry eye.[17] Noninvasive keratography breakup time was measured, using a Keratograph 5M, as the time from the completion of a blink to the distortion of the ring pattern. The median of three repeated measurements was recorded. A noninvasive keratography breakup time of <10 seconds was defined as a positive homeostasis marker of dry eye.[14] The external eye examination was performed with a Keeler Symphony Slit Lamp (Keeler UK, Windsor, United Kingdom). The ocular surface staining was assessed with two vital stains: (i) corneal staining with fluorescein and (ii) conjunctival staining and lid-wiper epitheliopathy with lissamine green.[14] More than five corneal spots of fluorescein staining and/or more than nine conjunctival spots of lissamine green,[14] and/or a lid-wiper epitheliopathy ≥2 mm in horizontal length staining and/or ≥25% sagittal width staining (excluding the line of Marx)[18] were considered positive homeostasis markers for dry eye disease.[14] The meibum quality and the number of meibomian glands yielding liquid secretion were assessed using the slit lamp, with gentle pressure applied using a cotton bud to express the glands along the lower eyelid. The five central glands were assessed and scored on a scale from 0 to 3 by the number of expressible glands. The grade was defined as follows: grade 0 for five expressible glands, grade 1 for three to four expressible glands, grade 2 for one to two expressible glands, and grade 3 when no glands were expressible.[19] The quality of the expressed meibum from each of the central eight glands was scored on a scale from 0 to 3,[19] defined as grade 0 for clear oil; grade 1 for cloudy secretion; grade 2 for cloudy, granular secretion; and grade 3 for a toothpaste-like secretion. The scores of each of the eight central glands were summarized (0 to 24), giving a maximum possible expressibility score of 24.[19] Meibomian gland dysfunction was diagnosed according to the recommendations of the diagnostic subcommittee of the meibomian gland dysfunction workshop (2011).[19] A positive diagnosis of meibomian gland dysfunction was defined by a meibum expressibility grade ≥1 and a meibum quality score ≥4.[19] Meibomian gland dysfunction was considered a sign of evaporative dry eye.

We diagnosed dry eye disease based on the following criteria: an OSDI score ≥13 and at least one positive homeostasis marker of dry eye (i.e., shorter noninvasive keratography breakup time, higher ocular surface staining, or increased osmolarity).[19] Patients with dry

eye disease with meibomian gland dysfunction and normal tear meniscus height were subclassified as evaporative dry eye. Those who did not have meibomian gland dysfunction but exhibited lower tear meniscus height were subclassified under aqueous deficient dry eye.[14] Patients with dry eye disease with both meibomian gland dysfunction and lower tear meniscus height were classified under mixed dry eye disease. The symptomatic patients who did not have meibomian gland dysfunction and had normal tear meniscus height were classified as having other ocular diseases.

All statistical analyses were performed with IBM SPSS Statistics version 26 (IBM SPSS Statistics, Armonk, NY) using standard parametric or nonparametric statistical tests, including the χ^2 test, Mann-Whitney *U* test, Spearman correlation, and multivariate linear regression. $P < .05$ was considered statistically significant. The variables associated with vision-related quality of life were analyzed by Spearman correlation and multivariate linear regression. Variables with $P \leq .25$ from the correlation analysis were entered into the multivariate linear regression model.

The research adhered to the principles of the Declaration of Helsinki (Code of Ethics of the World Medical Association) and obtained the approval of the Regional Committee for Medical Research Ethics for the Southern Norway Regional Health Authority (2017/2542/REK sør-øst). All participants provided written, informed consent to participate in the study.

RESULTS

A total of 49 patients who had attended a routine eye examination participated in the study. Of these, 29 (59%) were female. The mean ± standard deviation (SD) age of the participants was 48 ± 13 years (range, 20 to 68 years), and there was no statistically significant difference in the mean age between women and men.

Table 1 presents an overview of habitual visual acuity, best-corrected visual acuity, risk factors, dry eye symptoms, and the clinical findings of dry eye disease for all participants.

The mean ± SD habitual visual acuity was the logarithm of the minimum angle of resolution –0.05 ± 0.15; the habitual visual acuity was statistically significantly different between men and women (–0.11 vs. 0.00; *t* test, $P = .17$) and correlated with age ($r^2 = 0.282$, $P = .05$). The best-corrected visual acuity was statistically significantly better than habitual visual acuity (mean difference logarithm of the minimum angle of resolution, –0.02 ± 0.05); however, it was not clinically significantly better (<1 line of improvement).

Twenty participants (41%) reported ocular allergy, nine (18%) were contact-lens wearers, and seven (14%) smoked daily. None of the patients had a known diagnosis of corneal neuropathic pain, one had ocular albinism, and eight had known systemic disease; seven had cardiovascular disease, four had atopic disease, two had depression,

TABLE 1. Visual acuity and risk factors and clinical findings of dry eye disease

	All participants (n = 49)	Participants with dry eye disease (n = 29)	Participants without dry eye disease (n = 20)
Habitual visual acuity, mean ± SD	–0.05 ± 0.15	0.05 ± 0.13	–0.06 ± 0.18
Best-corrected visual acuity, mean ± SD	–0.10 ± 0.07	–0.10 ± 0.06	–0.10 ± 0.07
Disease history			
Ocular disease, n (%)	1 (2)	0 (0)	1 (5)
Ocular lubricants, n (%)	4 (8)	4 (14)	0 (0)
Systemic disease, n (%)	8 (16)	5 (17)	3 (15)
Risk factors			
Ocular allergy, n (%)	20 (41)	13 (45)	7 (35)
Contact lens wear, n (%)	9 (18)	6 (15)	3 (21)
Smoking*, n (%)	7 (14)	4 (15)	3 (14)
Screen time, mean ± SD	4.8 ± 2.6	5.0 ± 2.1	4.6 ± 2.1
Eyelid surgery	3 (6)	2 (7)	1 (5)
Symptoms			
Ocular surface disease index score,† mean ± SD	25 ± 20	35 ± 19	10 ± 10
Clinical diagnostic signs			
Staining‡	21 (43)	12 (41)	9 (45)
Osmolarity§	32 (65)	22 (76)	10 (50)
Noninvasive keratograph breakup time‖	16 (33)	9 (31)	7 (35)
Clinical subdiagnostic signs			
Meibomian gland dysfunction**	29 (49)	16 (55)	13 (65)
Tear meniscus height††	14 (29)	9 (31)	5 (25)

*One or more cigarettes a week. †Statistically significant difference: Wilcoxon rank sum test, $P \leq .001$. ‡Staining (lid-wiper epitheliopathy of ≥2 mm in horizontal length and/or ≥25% sagittal width and/or more than five corneal spots of fluorescein staining and/or more than nine conjunctival spots of lissamine green staining). §Osmolarity ≥308 mOsm/L in either eye or interocular difference >8 mOsm/L. ‖Noninvasive keratograph breakup time <10 seconds. **Meibomian gland dysfunction (secretions grade ≥4 and expressibility ≥grade 1). ††Tear meniscus height <0.2 mm. SD = standard deviation.

and one had thyroid disease. All participants used computer screens, and the mean ± SD reported screen time per day was 4.8 ± 2.6 hours.

The mean ± SD OSDI score of the participants was 25 ± 20. The OSDI score was not associated with sex, age, contact lens usage, smoking, ocular allergy, or computer screen time. Of the 49 participants, 33 (67%) had dry eye symptoms, with 14 (42%), 5 (15%), and 14 (42%) exhibiting mild, moderate, and severe symptoms, respectively. Furthermore, 41 participants (84%) had one or more positive homeostasis markers of dry eye disease. The diagnostic signs of dry eye disease (i.e., shorter noninvasive keratography breakup time, higher ocular surface staining, or increased osmolarity) were more frequent in women than in men (93% vs. 70%, $P = .03$); however, these were not associated with age or dry eye symptoms. In total, 29 participants (59%) were diagnosed with dry eye disease. Fig. 1 shows an overview of patients with the symptoms and signs of dry eye disease.

The mean ± SD age of the patients with dry eye disease was 50 ± 12 years. There was no statistically significant difference in habitual visual acuity or best-corrected visual acuity between participants with and without dry eye disease. Furthermore, dry eye disease was not associated with age, ocular allergy, contact lens usage, smoking, or screen time. However, the disease was more frequent in women than in men (72% vs. 40%, $P = .02$).

Meibomian gland dysfunction was found in 29 participants (59%), whereas 14 (29%) had lower tear meniscus height. Meibomian gland dysfunction and lower tear meniscus height were not associated with sex, age, dry eye symptoms, homeostasis markers of dry eye disease, contact lens usage, smoking, or ocular allergy. Table 2 shows the subclassification of dry eye disease based on sex.

The patients with dry eye disease had a lower National Eye Institute 25-item Visual Function Questionnaire composite score than the patients without dry eye disease (83 ± 9 vs. 93 ± 6 points; Mann-Whitney U test, $P < .001$). Table 3 presents the National Eye Institute 25-item Visual Function Questionnaire composite and subscale scores for patients with and without dry eye disease.

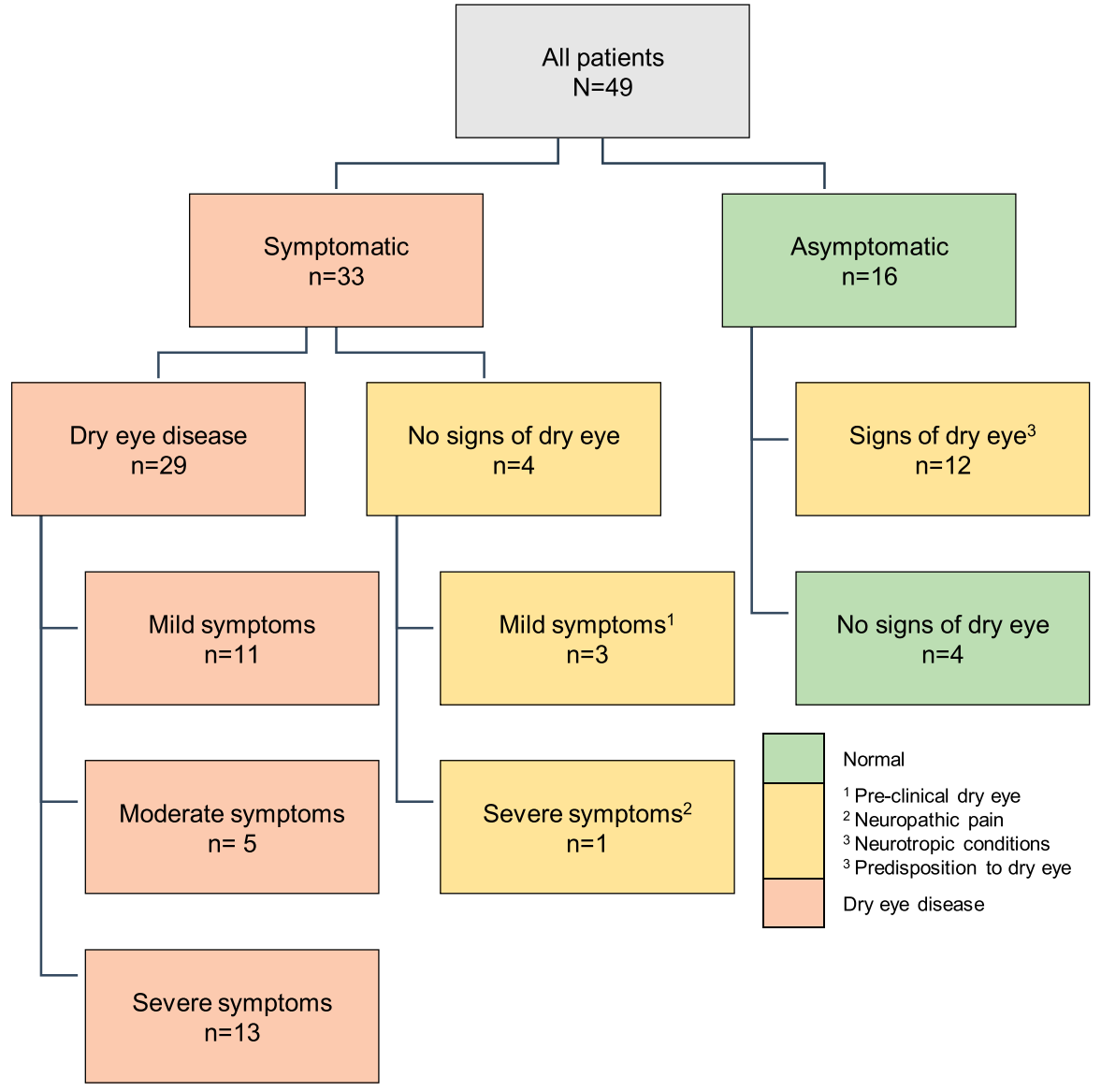

FIGURE 1. Overview of patients with symptoms and signs of dry eye disease.

TABLE 2. Dry eye disease subcategories by sex (n [%])

	All (n = 29)	Female (n = 21)	Male (n = 8)
Evaporative dry eye disease*	10 (34.5)	8 (38)	2 (25)
Mixed dry eye disease†	6 (21)	5 (24)	1 (12.5)
Aqueous deficient dry eye disease‡	3 (10)	3 (14)	0 (0)
Unclassifiable§	10 (34.5)	5 (24)	5 (62.5)

*Patients with dry eye disease and meibomian gland dysfunction (secretions grade ≥4 and expressibility ≥grade 1) with tear meniscus height >0.2 mm. †Patients with dry eye disease and both meibomian gland dysfunction (secretions grade ≥4 and expressibility ≥grade 1) and tear meniscus height <0.20 mm. ‡Patients with dry eye disease and tear meniscus height <0.2 mm without meibomian gland dysfunction. §Patients with dry eye disease without meibomian gland dysfunction (secretions grade ≥4 and expressibility ≥grade 1) and tear meniscus height > 0.2 mm.

Dry eye disease was negatively correlated with the National Eye Institute 25-item Visual Function Questionnaire subscale scores for general vision, ocular pain, near activities, distance activities, vision-specific social functioning, mental health, role difficulties, and driving but not with the subscale scores for general health, dependency, color vision, or peripheral vision. Table 4 shows the correlation between the National Eye Institute 25-item Visual Function Questionnaire subscale scores and dry eye disease, age, sex, habitual visual acuity, contact lens usage, ocular allergy, and smoking.

Compared with the patients without dry eye disease, the ones with dry eye disease reported experiencing more ocular pain (65 ± 19 vs. 80 ± 19; Mann-Whitney *U* test, $P = .007$) and more vision-specific role difficulties (64 ± 20 vs. 83 ± 18; Mann-Whitney *U* test, $P = .001$). Dry eye disease was an independent predictor of both ocular pain and a reduced score for vision-specific role difficulties.

A multivariate linear regression model was calculated to predict the ocular pain score based on the participants' sex, age, smoking, and dry eye disease. A significant regression equation was found ($F_{4,44} = 4.550$, $P = .001$), with an r^2 of 0.328. The participants' predicted general vision score was equal to 92.603 – 14.289 (dry eye disease) + 3.008 (SEX) – 0.232 (AGE) – 21.008 (smoking). The participants with dry eye disease scored 14.289 points less than those without dry eye disease, men scored 3.008 points more than women, and smokers scored 21.008 points less than nonsmokers. Only smoking and dry eye disease were statistically significant predictors.

A multivariate linear regression model was calculated to predict the role difficulty score based on the participants' sex, age, habitual visual acuity, and dry eye disease. A significant regression equation was found ($F_{4,44} = 3.480$, $P = .008$), with an r^2 of 0.263. The participants' predicted role difficulty score was equal to 77.703 – 19.235 (dry eye disease) + 2.288 (SEX) – 0.067 (AGE) – 29.250 (habitual visual acuity). The participants with dry eye disease scored 19.235 points less than those without dry eye disease, men scored 2.288 points more than women, and the participants' role difficulty score decreased by 0.67 points with each decade of age and increased by 2.93 points with each line (0.1 log unit) further down on the visual acuity chart.

Habitual visual acuity was an independent predictor of a reduced score for distance activities, vision-specific social functioning, and dependency. Both dry eye disease and habitual visual acuity were independent predictors of reduced general vision, a reduced score for near activity, driving, and vision-specific mental health.

TABLE 3. Mean ± SD National Eye Institute 25-item Visual Function Questionnaire score for patients with and without dry eye disease

	Participants with dry eye disease (n = 29)	Participants without dry eye disease (n = 20)
Composite score*	83 ± 9	93 ± 6
Subscale scores		
General health	63 ± 24	67 ± 22
General vision†	73 ± 14	87 ± 14
Ocular pain†	65 ± 20	82 ± 19
Near activities†	78 ± 19	91 ± 14
Distance activities‡	87 ± 11	96 ± 6
Vision specific		
Social functioning‡	93 ± 9	99 ± 3
Mental health*	74 ± 13	92 ± 7
Role difficulties*	63 ± 20	86 ± 17
Dependency	96 ± 7	99 ± 4
Driving†	85 ± 14	95 ± 10
Color vision	98 ± 7	99 ± 6
Peripheral vision	91 ± 14	97 ± 8

Statistically significant difference: Mann-Whitney *U* test. *$P < .001$. †$P < .01$. ‡$P < .05$.

DISCUSSION

To our knowledge, no previous study has evaluated how dry eye disease, diagnosed according to the Tear Film & Ocular Surface Society International Dry Eye Workshop II guidelines, affects the vision-related quality of life in the Norwegian optometric population. The findings in this study support a previous study reporting a high number of dry eye disease among patients examined in Norwegian optometric practice.[7] Furthermore, this study demonstrates that patients with dry eye disease experience reduced vision-related quality of life compared with patients without dry eye disease. The patients with dry eye disease reported that, because of their eyesight, they accomplished less in their personal and professional lives than intended and were restricted in how long they could work or engage in other activities. They also reported more difficulties with both distance and near vision tasks compared with the patients without dry eye disease. This corresponds to previous studies that reported dry eye disease exerting adverse effects on people's ability to read, carry out professional work, use the computer, and perform other important daily tasks.[5,20,21] Moreover, in the current study, a multivariate linear regression model has shown that dry eye disease influences performance at work and daily life more than habitual visual acuity does. To the best of our knowledge, no previous study has evaluated and

TABLE 4. Correlation between subscale scores of the vision-related quality of life and dry eye disease, age, sex, habitual visual acuity, contact lens wear, ocular allergy, and smoking

	Age	Sex	Habitual visual acuity	Dry eye disease	Contact lens wear	Ocular allergy	Smoking
General health	–0.300	0.298*	–0.150	–0.124	–0.179	0.030	–0.238
General vision	–0.222	0.347*	–0.587†	–0.401†	–0.050	0.063	–0.227
Ocular pain	–0.290*	0.197	–0.235	–0.389†	0.083	–0.219	–0.385*
Near activities	–0.418†	0.109	–0.333*	–0.375†	0.044	–0.182	–0.255
Distance activities	–0.274	0.349*	–0.374†	–0.386†	0.016	–0.089	0.049
Vision specific							
Social functioning	–0.069	0.135	–0.167*	–0.302*	–0.036	–0.249	–144
Mental health	–0.285*	0.421†	–0.464*	–0.495†	0.059	–0.085	–0.241
Role difficulties	–0.084	0.264	–0.163	–0.478†	–0.093	–0.225	–0.025
Dependency	–0.001	0.131	–0.306*	–0.192	–0.124	–0.167	–0.237
Driving	–0.168	0.200	–0.302*	–0.390†	0.103	0.054	–0.217
Color vision	–0.184	–0.134	–0.203	–0.039	0.121	–0.134	–0.139
Peripheral vision	0.071	0.084	–0.106	–0.259	0.187	–0.143	–0.272

Statistically significant Spearman correlation. *$P < .05$. †$P < .001$.

explored these associations. This finding may imply that patients examined in optometric practice may experience reduced productivity at work because of dry eye disease despite possessing good visual acuity; it also highlights that a healthy tear film is an important contributor to workplace performance. Modern work life increasingly requires near work, such as looking at screens at a close distance, for a prolonged period. Moreover, our real-world experiences are continuously and increasingly blending with the online world.[22] Because good vision and healthy eyes are essential to workplace performance as well as participation in the digital world, optometrists should not underestimate the impact of dry eye disease on visual performance; furthermore, they should be cognizant that good near vision may require more than visual display unit correction. In addition, optometrists must be aware that near work is associated with incomplete and reduced frequency of blinking, which leads to the desiccation of the ocular surface and the worsening of dry eye disease.[8] They should provide patients with the appropriate advice, for example, reducing screen time or lowering and correctly adjusting the height of computer screens to reduce the evaporation of tears due to a smaller ocular aperture.[23] Patients should be advised to use artificial tears, take breaks, avoid screen glare, and stay hydrated. In this study, dry eye disease was also correlated with reduced vision-specific mental health; in essence, compared with the patients without dry eye disease, those with it reported feeling more worried and frustrated about their eyesight, having less control over what they do, and being more afraid of embarrassing themselves and others because of their eyesight. The association between dry eye disease and depression is known, and antidepressant agents may decrease lacrimation.[24] Moreover, reduced vision-related quality-of-life scores in dry eye disease are associated with anxiety and depression.[25] However, the precise mechanisms behind the association between dry eye disease and depression have yet to be fully understood.[1] Although our study did not explore this association, we acknowledge the mutual association between mental health and dry eye disease. Patients on medications to treat depression are at a higher risk of developing dry eye disease.[24] Furthermore, dry eye disease may worsen the symptoms of depression because of eye discomfort and ocular pain.[26] Living in a state of happiness is considered to improve human function, and positive psychology interventions have been suggested as part of the treatment for dry eye disease.[8]

Ocular pain is one of the defining features of dry eye disease.[26] In the current study, the participants with dry eye disease had more frequent and more intense ocular symptoms than those without dry eye disease; this is in line with previously reported results.[25] Unlike pain, discomfort is usually less intense and not necessarily related to tissue damage, whereas pain is associated with actual or potential tissue damage or resembles the unpleasant sensory experience associated with actual or potential tissue damage. Untreated pain, regardless of its source, impacts the quality of life at any age.[27] Pain has negative consequences for both patients and their families; it negatively affects patients' social and professional life and ideally should be prevented. The treatment should minimize the efforts required from patients as well as health care professionals.[28,29] Pain can also negatively affect productivity at work.[30] Therefore, providing patients with advice and awareness about dry eye disease at an early stage, before it worsens, is essential to prevent pain and promote healing. Through accurate diagnosis and treatment, optometrists can reduce the negative effects of pain on their patients and contribute to enhancing their vision-related quality of life. Patient-reported outcomes on the quality of life facilitate the assessment and monitoring of dry eye disease.[31]

Because ocular pain was more substantial among smokers than nonsmokers, optometrists should consider advising patients with dry eye disease to stop smoking.[32] Ocular pain was not associated with contact lens usage or ocular allergy, although these two factors are known to be associated with ocular discomfort.[33,34] This association might have been absent because the contact lens wearers were well fitted with their lenses and because the patients with ocular allergies effectively managed their allergies and prevented their symptoms.

Dry eye disease was more prevalent in female than in male individuals; this is in line with the Tear Film & Ocular Surface Society International Dry Eye Workshop II report, which states that female individuals are more likely to have dry eye disease and that the female

sex is a major risk factor for dry eye disease.[35] On the other hand, this may also reflect that female individuals typically use health care services more often than male individuals and that male individuals seek professional help at a later stage in life and have a more severe state of disease than women.[36] In the multivariate linear regression model, we found that age and sex were not significant predictors of ocular pain. Optometrists should therefore be aware of these sex-related differences and educate their patients on the importance of early diagnosis and the potential consequences of negligence. A previous study found female individuals to be 6 years younger than their male counterparts at the time of dry eye disease diagnosis,[37] whereas another found age to be a risk factor for dry eye disease.[1] In our study sample, there was no significant difference in age between men and women with regard to dry eye disease. Another major study has suggested that sex differences in dry eye disease may lessen with advanced age[38]; because the mean age in our study is low, a difference in dry eye disease between women and men is in line with expectations.

When adjusting for sex, smoking, and dry eye disease in the multivariate linear regression model, age was not a significant predictor of ocular pain. There is a consensus in dry eye research that age is a risk factor for dry eye disease.[1] Moreover, corneal sensitivity is lower in patients with dry eye disease because of disease severity and subtypes.[1,39] This may influence how patients report their dry eye disease symptoms and their experience of ocular pain.

Furthermore, the effect of a disease or condition varies based on a patient's perception as well as their pain or distress threshold.[39] Severe dry eye disease has a similar effect on the quality of life as mild psoriasis or moderate to severe angina pectoris.[40] The sensation of pain may explain why people with dry eye disease must limit their working hours or spend less time doing vision-demanding leisure activities.[28] Moreover, reduced vision is easier to accept, suppress, or correct with the appropriate optical aids or by adapting to the task at hand compared with living with painful, sore, and gritty eyes. By managing and providing optimal care for patients with dry eye disease, optometrists can reduce the prevalence of the disease, lessen the negative consequences of self-perceived health status, and alleviate the psychological stress resulting from the disease.[41]

In our study, the patients with dry eye disease had lower habitual visual acuity compared with the patients without dry eye disease. The association between dry eye disease and visual acuity is poorly documented in the literature. However, patients with dry eye disease are expected to have poorer visual acuity than those without it when visual acuity is measured after the suspension of blinking; this is because visual quality worsens when the tear film breaks up, causing higher-order aberrations and blurring.[42] Moreover, dry eye disease has a deteriorating effect on patients' self-perceived visual acuity.[25] Compared with other studies investigating the impact of eye diseases on self-perceived vision, our study found that patients with dry eye disease rate their general vision better than patients with wet age-related macular degeneration[43,44] and keratoconus in one or both eyes[45]; however, they rate it poorer than patients with corrected refractive errors,[46] as well as patients with healthy eyes and normal vision.[47] Notably, insufficient correction of ametropia can affect the OSDI score; furthermore, patients with dry eye disease may achieve better visual acuity if they are encouraged to blink during the assessment.[14] In general, patients with dry eye disease blink more than those without it.[20] Hence, an optometrist should measure patients' blink rate and establish the Ocular Protection Index score to identify factors that may cause or worsen dry eye disease.[48]

The strengths of this study include one optometrist collecting all the data, which eliminated the risk of interobserver errors, and the selection of two questionnaires to measure the impact of dry eye disease on vision-related quality of life, which provided greater certainty of findings.[49] The OSDI questionnaire was used to identify dry eye symptoms and as a diagnostic tool for dry eye disease. The National Eye Institute 25-item Visual Function Questionnaire was used to measure the impact of dry eye disease on vision-related quality of life. However, this study has some limitations. The small sample size limits the generalizability. However, a post hoc analysis of the two multiple linear regression models applying a precision (α) of 5% showed a power ranging from 0.91 to 0.98. As the OSDI[13] and National Eye Institute 25-item Visual Function Questionnaire[11] are designed for summary scoring, we chose to use summary scoring. However, summary scoring has some limitations because it assumes that all the items are of equal difficulty and that the change between response options is equal.[50] Moreover, both the OSDI and the National Eye Institute 25-item Visual Function Questionnaire show evidence of multidimensionality and poor validity of subscales.[51,52] The use of a vision-related quality-of-life questionnaire using Rasch analysis could have provided better information and interpretation of the vision-related quality of life. The examination was undertaken during the allergy season, which could have influenced the symptoms and clinical signs of those patients with seasonal allergies. However, ocular allergies were not correlated with dry eye disease. Although the lack of correlation may also be due to the sample size, as the study was not powered to identify associations between dry eye symptoms and ocular allergy. The osmolarity measurement was performed at the beginning of the examination, which might have influenced the noninvasive keratography breakup time measurements. The same strips of fluorescein and lissamine green dyes were used for both eyes, and the fluorescein staining was assessed after the fluorescein breakup time measurements without reinstallation. This might have influenced the distribution of dye between the eyes and led to an underestimation of the degree of corneal staining in the last eye measured. Because our data were analyzed at the individual level, it is unlikely that dry eye disease was underdiagnosed. Finally, as the symptoms and consequently dry eye disease were influenced by the nature of symptom reporting, the patients could have misunderstood the questionnaire items and underestimated or overestimated the severity of their symptoms.[53,54] Moreover, the patient-reported symptoms might have been influenced by the participants' varying tolerance to pain and discomfort.[55] This could have led to more severe forms of dry eye disease being treated as less severe, and vice versa. The consideration of other clinical factors, such as medication history, nonocular pain, and systemic condition, could have supported our conclusion further.

Our findings imply that the prevention, diagnosis, and treatment of dry eye disease fall under the scope of optometric practice and that optometrists can contribute to the maintenance and restoration of patient's vision and quality of life, in addition to preventing the reduction of work productivity. Half of the patients examined in Norwegian optometric practice have a dry eye disease that requires medical advice or targeted treatment.[7] Consequently, if dry eye disease is misdiagnosed or not properly managed, optometrists could be at risk of misinterpreting their clinical findings and making suboptimal clinical decisions. Undiagnosed dry eye disease may result in the prescription of new spectacles or contact lenses, which would not help patients because unstable or suboptimal vision could be the result of dry eye disease. In Norway, optometry is at the primary care level, whereas ophthalmology is at the secondary level of the health care system. According to the standards of optometric care in Norway, ocular symptoms questionnaires and dry eye diagnostics are not part of the routine eye examination.[56] Additional examination is

indicated if the patient reports symptoms. However, a dry eye workup is not mandatory, and the proportion of our sample that would have been identified as having dry eye is uncertain. In the worst case scenario, none in the study sample would have been identified with dry eye disease, as identification of dry eye disease requires specific, systematic examination. Based on the findings in this study, we advise optometrists to screen for dry eye symptoms in adults, as well as to assess the breakup time, ocular surface staining, and meibomian glands during routine examinations[7] to identify patients with dry eye disease and patients at risk of developing dry eye disease. Screening and preventive intervention at an early stage of dry eye disease can delay the onset of its more serious forms among young adults.[2]

CONCLUSIONS

In this study, dry eye disease was an independent predictor of ocular pain and vision-specific difficulties, as well as reduced general vision, near vision, and (vision-specific) mental health. Optometrists should consider dry eye disease as a cause of reduced vision and quality of vision. The adverse effects of dry eye disease on vision-related quality of life are a public health issue. We propose that screening for dry eye disease, thus ensuring its early identification and treatment, in Norwegian optometric practice can promote better vision and health among patients.

ARTICLE INFORMATION

Supplemental Digital Content: Appendix Table A1, available at http://links.lww.com/OPX/A691, provides an overview of the sub-scales and questions in the National Eye Institute 25-Item Visual Function Questionnaire.

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All the participants gave informed consent to participate in the study.

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