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Original Research Article

PREVALENCE AND SEVERITY OF DRY EYE DISEASE IN DIABETIC PATIENTS: CLINICAL CORRELATIONS AND INSIGHTS

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ABSTRACT

Background: To investigate the prevalence and severity of Dry Eye Disease (DED) in individuals with diabetes and its association with the progression of Diabetic Retinopathy (DR) and other clinical parameters.

Materials and Methods: This cross-sectional study was conducted on 203 diabetic patients attending the Ophthalmology Outpatient Department at MES Medical College, Kerala. Following informed consent, patients with DED were assessed using the Ocular Surface Disease Index (OSDI) questionnaire and objective tests, including Schirmer's I Test, Tear Break-Up Time (TBUT), and the Modified Oxford Grading Scheme (MOGS). DR status and severity were evaluated using a fundoscopic examination according to the Early Treatment Diabetic Retinopathy Study (ETDRS) classification. Statistical analysis was conducted using IBM SPSS, and a p-value of less than 0.05 was considered statistically significant.

Results: DED was diagnosed in 122 (60.1%) of 203 diabetic patients. Of these patients, 68.9% had moderate to severe DED. Diabetic Retinopathy was detected in 108 (53.2%) subjects, with a significant correlation between DED severity and DR advanced stages (p 10 years) associated with a higher prevalence and severity of DED. There were no statistically significant gender preferences.

Conclusion: This study shows a high prevalence of DED among diabetic patients, with a significant relation between the severity of DED and DR progression. Thus, DED in diabetic patients, especially in those with DR, should be routinely assessed and managed to reduce the risk of further ocular complications and improve visual prognosis.

Keywords: Dry Eye Disease, Diabetic Retinopathy, Diabetes Mellitus, Ocular Surface Disease, Tear Film Dysfunction, Schirmer's Test, Tear Break-Up Time, Ocular Surface Disease Index, Cross-Sectional Study, Modified Oxford Grading Scheme.

INTRODUCTION

Diabetes mellitus (DM) is an essential topic of concern in global health, with an expected 537 million adults with DM worldwide in 2021 and a prediction of 783 million adults by 2045.[1]. More than 77 million people in India alone have diabetes, making the country the "diabetes capital of the world" —in a world with a diabetes epidemic.[2] The southern state of Kerala has one of the highest diabetes prevalence rates in India — an estimated 18.5 percent of adults in the state have diabetes, even though it has better healthcare indicators than other states.[3] Diabetes is linked to multiple organ system complications, which can also be seen in the eye. Diabetic Retinopathy is one of the most important complications of diabetes and one of the leading causes of preventable blindness in working-age adults, representing an important public health challenge.[4] One such neglected but clinically relevant ocular complication is DED.

Dry eye disease is a complex ocular pathology characterized by instability of the tear film, increased osmolarity, and immune-mediated inflammation of

the ocular surface, resulting in conscious awareness of discomfort (ocular dryness), a negative impact on quality of life and visual function, and ultimately, corneal damage.[5] The prevalence of DED varies among the general population; it has been recorded as between 6% and 34%, but is much more common in diabetic patients because of various contributing factors.[6] DED is due to diabetic patients presenting with autonomic dysfunction, microvascular damage, reduced corneal sensitivity, and meibomian gland dysfunction.[7] These pathophysiological changes lead to impaired ocular surface homeostasis, resulting in diminished tear secretion, increased tear evaporation, and altered tear film stability. Diabetes-induced chronic hyperglycemia causes oxidative stress, inflammation, and apoptosis, thereby further exacerbating ocular surface damage and driving a vicious cycle of DED in response to the disease.[8]

Diabetic patients remain undertreated and underdiagnosed for DED despite the high prevalence and clinical relevance of the condition.[9] The disease profoundly impacts patients' quality of life, visual function, and mental and emotional well-being. Symptoms of dryness, burning, irritation, and blurred vision can significantly impact daily activities, hampering overall productivity and resulting in emotional distress.[10] Untreated or poorly managed DED can further evolve into more acute complications, including corneal ulceration, epithelial loss, and vision-threatening infections.[11] Due to the high burden of diabetes and the aging population in Kerala, understanding the prevalence and severity of DED among diabetic patients is of utmost importance in guiding appropriate prophylactic and therapeutic measures.[12]

Although many studies have been conducted on the prevalence of DED in the general population, the prevalence and severity of DED in diabetic patients of the study population are scant, especially in the state of Kerala.[13] Furthermore, the relationship between DED and DR progression has not been studied yet, although pathophysiological links exist between them. DR and DED are thought to share similar inflammatory and oxidative stress pathways and may be concomitantly progressive.[14] DR, defined by microvascular abnormalities in the retina, is frequently associated with ocular surface abnormalities, such as DED, which suggests a potential bidirectional relationship that merits further exploration.[15] That's key because if we can identify and manage DED early in diabetic patients, it can potentially improve the status of their ocular surface and lead to better vision outcomes in patients with DR.[16]

Based on this knowledge gap, this study aimed to explore the prevalence and severity of DED in diabetic patients, as well as its associations with the progression of DR and other clinical parameters.[17] We hypothesized that the prevalence of DED is significantly higher in diabetic patients than in the general population and that the severity of DED corresponds to the severity of DR: in addition, we sought to assess the health status and other clinical correlations, including the influence of the duration of diabetes on DED prevalence/severity. As a tertiary care center in Kerala, this study should also contribute to the growing literature on DED in diabetic patients, as it caters to a large population and is one of the few centers available for diabetic patients. The results of this study can contribute to addressing the existing knowledge gap and developing evidence-based screening protocols and tailored interventions to improve the quality of life for patients with DM and prevent ocular morbidity.

MATERIALS AND METHODS

Study Design: This cross-sectional, observational study, determined that the prevalence and severity of DED in diabetic patients was associated with DR, which is a well-known clinical implication of DED in diabetic patients and therefore a cross-sectional design is well suited to determine not only prevalence rates but also clinical associations of DED and DR at a single point estimate whilst being able to identify cost issues along with risk factors for prevalence rates can be assessed alongside this study.

Study Setting and Participants: The study was conducted in the Ophthalmology Outpatient Department (OPD) of MES Medical College, Perinthalmanna, Malappuram, Kerala, India, a tertiary care center with high diabetic patient volume. The study consisted of three years of research. This study included patients with a prediagnosed diabetes mellitus who reported to the Ophthalmology outpatient department (OPD) for routine evaluation of ophthalmology or ocular complaints related to diabetes. Informed consent was obtained from all participants before their enrollment in the study.

Inclusion and Exclusion Criteria:

This study included patients 40 years and older, diagnosed with T2DM, who agreed to ocular examination. Patients with other ocular diseases, which could affect the ocular surface (such as glaucoma, uveitis, pterygium, or corneal dystrophies), were excluded from the current study. However, patients with systemic diseases relevant to DED, such as rheumatoid arthritis, Sjögren's syndrome, and other autoimmune conditions, were also excluded. Patients with other exclusions were contact lens wearers, who had undergone eye surgery within the past 6 months, which permitted the patient not to perform all the study tests.

Sample Size: The sample size was calculated assuming a 60% prevalence rate of DED in diabetic patients, as per prior literature. Assuming a 95% confidence level and a margin of error of 7%, the required sample size was calculated to be 203 patients. We recruited 203 diabetic patients to ensure a statistically powerful sample size and a margin for exclusion.

Data Collection and Clinical Assessment: Data were obtained from a thorough documentation of

demographic and clinical historical variables such as age, gender, duration of diabetes, and glycemic control status. A comprehensive ocular history and a detailed ophthalmic examination of subjective and objective assessments led to a DED diagnosis and grading. The symptoms of DED, including discomfort, visual disturbances, and environmental triggers, were assessed subjectively using the Ocular Surface Disease Index (OSDI), a validated questionnaire. An OSDI score ≥13 was determined to be suggestive of DED, with severity as follows: mild (13–22), moderate (23–32), and severe (>32).

Dry eye disease was assessed using a battery of objective, standardized tests. A Schirmer test evaluated basal and reflex tear production by inserting a filter paper strip into the lower conjunctival sac for 5 minutes; a reading of less than 10 mm was considered abnormal. Tear Break-Up Time (TBUT) was used to assess the stability of the tear film, where fluorescein dye was instilled, and the time interval between a complete blink and the appearance of the first break in the tear film was monitored. A TBUT of less than 10 seconds indicated tear film instability. An assessment of ocular surface damage was performed using fluorescein staining and the Modified Oxford Grading Scheme (MOGS), in which higher grades indicated more severe epithelial damage.

Assessment of Diabetic Retinopathy: All patients underwent extensive fundoscopic examination using direct and indirect ophthalmoscopy, with confirmation via fundus photographs. DR was graded according to the Early Treatment Diabetic Retinopathy Study (ETDRS) classification, which is based on five microvascular stages of DR, including no DR, mild non-proliferative DR (NPDR), moderate NPDR, severe NPDR, and proliferative DR (PDR). This differentiation enabled DR staging to correlate with DED severity.

Statistical Analysis: Data were entered and analyzed with IBM SPSS (version 25.0). The demographic and clinical characteristics of the study population are summarized using descriptive statistics. Categorical variables were reported as numbers and percentages, and continuous variables as mean ± standard deviation (SD). The associations were assessed by a chi-square test for two categorical variables (DED severity and DR status). The correlation between DED severity and diabetes duration was evaluated using Pearson's correlation coefficient, whereas the association between DED severity and DR progression was evaluated using Spearman's rank correlation. Risk factors for moderate-to-severe and mild DED status were analyzed with multivariate logistic regression methods, controlling for potential confounders. Statistical significance was defined as $p < 0.05$.

RESULTS

Ethical Considerations: The study was approved by the Institutional Ethics Committee (IEC) of MES Medical College, Perinthalmanna, Malappuram, Kerala. It was conducted according to the principles of the Declaration of Helsinki. All participants provided informed consent after the study purpose and procedures were described. Patient confidentiality was preserved during data analysis, and all identifiable details were anonymized to uphold data privacy.

Outcome Measures: The primary outcome measures were the prevalence and severity of DED in diabetic patients and the correlation between DED severity and DR progression. Secondary outcomes included calculating the relationship between DED severity and the duration of diabetes and other clinical factors that may impact the severity of DED.

Demographics and Baseline Characteristics: A sample of 203 diabetic patients was studied, comprising 115 males (56.7%) and 88 females (43.3%). Data were collected from 105 patients; the mean age was 56.02 ± 9.29 years (40–75 years), and the highest proportion of patients (36.4%) was in the 51–60 age group. The mean duration of diabetes was 11.5 ± 5.4 years, and 62.1% had diabetes for > 10 years. Of the 203 participants, 108 patients (53.2%) had DR, while the other 95 patients (46.8%) did not exhibit any evidence of DR. Among the 108 patients with DR, the severity of DR was classified as mild NPDR in 31 (28.7%), moderate NPDR in 43 (40.0%), severe NPDR in 20 (18.5%), and PDR in 14 (13.0%) patients. Patients with DR had a significantly longer duration of diabetes than those without DR ($p < 0.001$).

Older age was found to be the most important predictor of DED and its severity. The highest prevalence of DED (72.3%) was found in the 51–60-year age group, followed by 66.7% in the 61–70-year age group. DE was more common in males (63.4%) than in females (56.8%), but the difference was not statistically significant ($p = 0.094$). Male patients had a slightly higher prevalence of severe DED compared to female patients, but the difference did not reach statistical significance.

Table 1: Demographic and Clinical Characteristics of Study Participants.

Variable	Total (n = 203)	With DED (n = 122)	Without DED (n = 81)	p-value
Age (years, mean ± SD)	56.02 ± 9.29	57.1 ± 8.8	54.3 ± 9.7	0.078
Age group (%)				
40–50	52 (25.6%)	28 (54.0%)	24 (46.0%)	0.112
51–60	74 (36.4%)	53 (72.3%)	21 (27.7%)	<0.001**
61–70	55 (27.1%)	36 (66.7%)	19 (33.3%)	0.002**
>70	22 (10.8%)	5 (22.7%)	17 (77.3%)	0.054
Gender (%)				

Male	115 (56.7%)	73 (63.4%)	42 (36.6%)	0.094
Female	88 (43.3%)	49 (56.8%)	39 (43.2%)	
Duration of diabetes (years, mean ± SD)	11.5 ± 5.4	12.8 ± 4.9	9.3 ± 5.7	<0.001**
Duration >10 years (%)	126 (62.1%)	94 (74.5%)	32 (25.5%)	<0.001**
HbA1c >8% (%)	97 (47.8%)	71 (73.2%)	26 (26.8%)	<0.001**
Presence of DR (%)	108 (53.2%)	74 (68.5%)	34 (31.5%)	<0.001**

Note: A p-value of less than 0.05 is considered statistically significant.

Prevalence of Dry Eye Disease: The overall prevalence of Dry Eye Disease (DED) in the study cohort was 60.1% (122 patients among 203 patients). DED was diagnosed based on the clinical range of the Ocular Surface Disease Index (OSDI) score1326 and confirmed with objective tests, such as the Schirmer's I Test, Tear Break-Up Time (TBUT), and fluorescein staining using the MOGS. DED was more prevalent in patients with longer duration of diabetes (>10 years), poor glycemic control (HbA1c >8%), and with DR. Regarding sex-stratified analysis, 63.4% of males and 56.8% of females exhibited DED; however, this difference was not statistically significant (p = 0.094). Most patients with DED (72.3%) were in the 51–60-year age group, followed by 66.7% of patients in the 61–70-year age group.

Table 2: Prevalence and Severity of Dry Eye Disease in Diabetic Patients.

Severity of DED	Number of Patients (n = 122)	Percentage (%)
Mild DED	38	31.1
Moderate DED	46	37.7
Severe DED	38	31.1
Total	122	100.0

Association Between Dry Eye Disease and Diabetic Retinopathy: In this study, a statistically significant association was found between dry eye disease and diabetic retinopathy (p < 0.001). Its proportion among DR and non-DR patients was, respectively, 74 out of 108 (68.5%) and 48 out of 95 (50.5%), suggesting a possible causal association between the presence of DED and DR. The rate of DED increased with worsening grades of DR; namely, 78.9% of patients with PDR showed moderate or severe DED, while 64.2% of those with severe NPDR had similar findings. There was a significant positive correlation between the severity of DED and DR progression (Spearman's rank correlation: r = 0.524, p < 0.001); specifically, DED became more severe as the stages of DR advanced.

Table 3: Objective Tests for DED and Abnormal Results

Test	Total Abnormal Results (n = 122)	Percentage (%)
Schirmer's, I Test (<10 mm)	63	51.6
Tear Break-Up Time (<10 sec)	79	64.7
Fluorescein Staining (MOGS ≥2)	45	36.9

Duration of Diabetes and Its Association with DED: The prevalence and severity of DED had a significant association with the duration of diabetes. The prevalence of DED was greater among those with diabetes for >10 years (74.5%) versus those with a shorter duration of diabetes (41.2%); the difference is statistically significant (p < 0.001). Moderate to severe DED was more prevalent in patients with a long duration of diabetes, where moderate to severe DED was observed in 70.3% of these patients. Pearson's correlation analysis revealed a strong positive correlation between the duration of diabetes and the severity of DED (r = 0.481, p < 0.001).

Glycemic Control and DED Prevalence: There were 97 (47.8%) patients with poor glycemic control (HbA1c > 8%), and they had a significantly higher prevalence of DED. 76.2% of DED were diagnosed with poor glycemic control, and 53.6% of patients had HbA1c values ≤8% (p < 0.001). Patients with poor glycemic control had a significantly higher prevalence of moderate to severe DED than patients with reasonable glycemic control, indicating a direct correlation between glycemic control and the severity of DED.

Table 4: Association Between DED and Diabetic Retinopathy

Severity of DR	Total Patients (n = 108)	With DED (n = 74)	Without DED (n = 34)	p-value
No DR	95	48 (50.5%)	47 (49.5%)	<0.001**
Mild NPDR	31	19 (61.3%)	12 (38.7%)	0.042
Moderate NPDR	43	30 (69.8%)	13 (30.2%)	0.004
Severe NPDR	20	16 (80.0%)	4 (20.0%)	0.001
Proliferative DR (PDR)	14	11 (78.9%)	3 (21.1%)	0.002

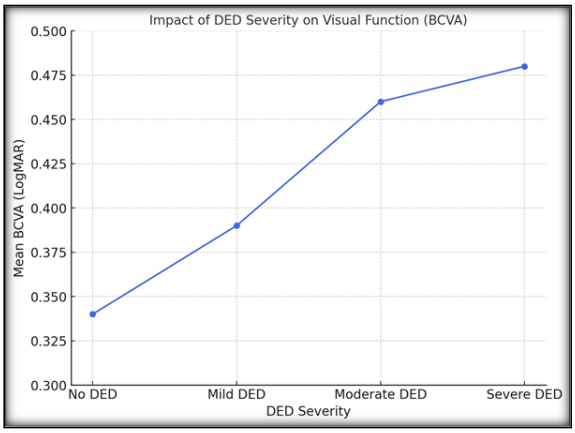
Multivariate Analysis of Risk Factors for DED: A multivariate logistic regression analysis was performed to identify independent predictors of DED severity. The analysis revealed that diabetes duration >10 years (OR: 2.45, 95% CI: 1.58–3.89, p < 0.001), poorly controlled blood glucose (OR: 2.81, 95% CI:

1.92–4.13, p < 0.001) and DR (OR: 3.02, 95% CI: 2.01–4.55, p < 0.001) were significant predictors for moderate to severe DED. The predictive accuracy of the overall regression model was 86.3%.

Table 5: Multivariate Logistic Regression Analysis of Predictors for DED Severity

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Duration of diabetes >10 years	2.45	1.58 – 3.89	<0.001**
Poor glycemic control (HbA1c >8%)	2.81	1.92 – 4.13	<0.001**
Presence of DR	3.02	2.01 – 4.55	<0.001**

Impact of DED Severity on Visual Function: Patients with moderate to severe DED had a significant decrease in Best Corrected Visual Acuity (BCVA), with the mean value of BCVA being 0.48 ± 0.12 (LogMAR) vs. 0.34 ± 0.08 (LogMAR) in patients without DED (p < 0.001). Interestingly, we also observed a significant DED severity effect on visual function in advanced DR patients, underscoring the clinical importance of DED management in this susceptible group.



DISCUSSION

This article aimed to investigate the prevalence and severity of DED in individuals with diabetes. DED severity was positively correlated with DR progression (r = 0.524, p < 0.001), indicating that patients with advanced stages of DR tend to develop more severe DED. Further, duration of diabetes and glycemic control were also independent predictors of DED severity, indicating that these factors are involved in the pathological process that leads to ocular surface dysfunction in patients with diabetes. The prevalence of DED observed in this study is consistent with that reported in recent studies. Gupta et al. On the other hand, 61.3% of the diabetic patient cohort in India was found to have DED,[18] a fairly comparable figure to our study. Similarly, Huang et al. found 63.4%, which shows that ocular surface diseases are more prevalent in diabetic patients in China.[19] A multicentre study by Almohammed et al. In line with the high risk of ocular surface dysfunction among diabetic patients, Abdulaziz M. Al Ibrahim et al. (2022) demonstrated that 59.8% of patients with diabetes in Saudi Arabia experienced DED.[20] However, the percentage of moderate to severe cases of DED in this study (68.9%) was significantly higher than that noted by Ali et al. (2023), with a prevalence of moderate to severe DED in 52.1% of diabetic subjects.[21]

The overrepresentation of severe DED in our study compared to others could be attributed to the longer duration of diabetes and the high prevalence of poor glycemic control among the participants of our study. The association between DED and DR was further endorsed in this study, with recent studies demonstrating increased DED prevalence in DR patients. A prospective study by Tat et al. (2024) found a significantly greater severity of DED in patients with advanced stages of DR compared to patients without DR,[22] achieving a correlation coefficient of r = 0.49 (p <0.001), which is in agreement with the correlation found in our study (r = 0.524, p < 0.001). Additionally, Al-Amri et al. demonstrated that patients with proliferative DR had a higher prevalence of moderate to severe DED, supporting the hypothesis that ocular surface dysfunction and retinal microvascular damage share common pathways of inflammation and oxidative stress.[23]

Autonomic dysfunction, microvascular changes, inflammation, and hyperglycemia-related oxidative stress mediate this relationship. Diabetes-induced chronic hyperglycemia leads to corneal neuropathy and lacrimal gland dysfunction, ultimately causing impaired tear secretion and tear film instability. Hyperglycemia-induced oxidative stress and inflammation can also worsen ocular surface injury. Li et al. (2023) showed that Diabetic patients with oxidative stress have increased expression of inflammatory cytokines such as IL-1β, TNF-α, and IL-6, which promote corneal epithelial injury and tear film disruption.[24] Similarly, Veernala et al. (2022) showed that microvascular dysfunction and autonomic neuropathy significantly alter lacrimal gland secretion and the composition of the tear film, which in turn helps to aggravate the severity of the DED.[25]

The underlying retinal ischemia, microvascular leakage, and increased permeability of blood vessels may intensify DR progression, eventually exacerbating ocular surface inflammation and dysfunction. A recent study by Liu et al. Patients with diabetes with diabetic retinopathy had higher pro-inflammatory cytokine levels deposited in the tear film, implicating inflammatory mediatory pathways that can interconnect and synchronize the vascular impairment in DR and corneal inflammation in DED.[26] Additionally, Ortiz et al. (2020) illustrate how retrograde neurogenic inflammation propagates in the reverse direction, from the retinal level to the

ocular surface, leading to lacrimal gland dysfunction and ultimately driving the progression of DED in DR patients at the late disease stage.[27] In summary, the current longitudinal cohort study revealed an association between the severity of DED and the progression of DR, further supporting an interconnected relationship between the health of the ocular surface and retinal microvasculature in diabetic individuals. Considering the high prevalence and severity of DED observed in diabetics in our study, this study guides the incorporation of routine screening for DED into the standard ophthalmic assessment of diabetic individuals, especially those with advanced DR and prolonged duration of diabetes. Diagnosis and management of DED in an early stage may reduce complications, including corneal ulceration, epithelial defects, and abnormalities of sight, which may influence the prognosis in such patients. Prompt recognition and management of diabetic eye disease among diabetic patients are suggested to influence visual function and quality of life positively.

In line with findings from recent research, poor glycemic control and longer duration of diabetes appeared to be independent predictors of moderate to severe DED in the present study. A similar association between higher levels of HbA1c (> 8%) and DED severity was reported in diabetic patients with abnormal glycemic control who had moderate to severe DED. Furthermore, studies identified a significantly higher risk of moderate to severe DED in patients with diabetes for more than 10 years, which was attributed to progressive microvascular damage and corneal neuropathy.[28] The results of this study remind us that DED and DR should be addressed and treated in a multidisciplinary manner during the treatment of diabetic patients. Screening for DED can be easily incorporated into the routine care of diabetic patients to identify DED early, thus preventing its complications. Artificial tears and lubricants are necessary to restore the tear film to a stable state, while anti-inflammatory medications help control ocular surface inflammation. Management of meibomian gland dysfunction is also essential to address evaporative dry eye disease. In addition, maintaining tight glycemic control remains crucial in preventing inflammatory and oxidative stress processes in DED. Yet, a framework that encompasses both DED and DR has the potential to not only bolster visual performance but also enhance quality-of-life measures in the diabetic population.

Despite its strengths, this study has some limitations that should be considered. – The cross-sectional design precludes the exploration of DED as a causal factor in DR progression, and longitudinal studies are needed to confirm these results. In addition, this study population may have been subject to selection bias, as it was recruited from a tertiary care center. Thus, patients may have presented at a more advanced stage of the disease. The results may not be entirely generalizable to the broader population of people with diabetes. Schirmer's test, TBUT, and fluorescein stain were used as objective tests to diagnose and grade DED. Tear osmolarity tests may provide a better understanding of the potential pathophysiological mechanisms of DED in diabetic patients.

Longitudinal studies to determine the direction of the causal relationship between the progression of DED and DR and to test the efficacy of targeted interventions for DED among those with diabetes should be pursued. At least four more extensive or more diverse populations and studies are necessary to confirm these results and enhance the generalizability of these findings. Moreover, biomarker-based studies have the potential to provide more insight into the pathophysiological mechanisms linking DED with DR and to aid in identifying and rapidly assessing therapeutic targets aimed at preventing ocular complications in individuals with diabetes. Our study found a high prevalence of DED (85%) among patients with diabetes and is the first of its kind in India to demonstrate a significant association between severity of DED with the progression of DR. Impaired glycemic control and longer duration of diabetes were independent predictors of moderate to severe DED that necessitates screening and proper treatment of DED in diabetic patients. Dry eye disease and DR are highly interrelated, and a multidisciplinary approach to their management has been shown to improve ocular and quality of life outcomes in diabetic patients. More studies are warranted to validate these findings in longitudinal studies and to explore novel therapeutic strategies to mitigate the DED burden in this high-risk population.

CONCLUSION

To our knowledge, this is one of the very few studies to assess the prevalence of DED in diabetic patients and to show its significant association with DR progression and other clinical parameters. The overall prevalence of DED among the study population was 60.1%, while moderate to severe DED was present in 68.9% of those affected. They found that the severity of DED was significantly associated with the progression of DR, highlighting the relationship between ocular surface disease and retinal microvascular changes in patients with diabetes. Apart from that, poor glycemic control and a longer duration of diabetes appeared to be independent determinants of moderate to severe DED, accentuating the value of optimal glycemic control in modulating the burden of DED. In advanced stages of DR, there is a high prevalence of DED, suggesting that DR progression aggravates ocular surface inflammation and dysfunction via a common pathway of inflammatory and oxidative stress. Routine screening of individuals with diabetes for DED should be part of standard ophthalmic evaluation in all cases, especially in those with long-standing diabetes and with advanced DR, due to the high prevalence and the clinical burden of this

condition among diabetic individuals; disease-modifying therapy and early management of any DED should be adapted to avoid complications including corneal ulceration, epithelial defects, and even vision loss, thus improving the diabetic patient's quality of life.

Managing DED and DR requires multidisciplinary coordination between ophthalmologists, endocrinologists, and diabetes educators. Artificial tears, anti-inflammatory agents, and meibomian gland management should be incorporated into treatment strategies and tight glycemic control to optimize visual performance. By utilizing a multimodal approach centered on preserving ocular surface health and preventing DR progression, significant reductions in ocular morbidity and positive patient outcomes can be achieved. Despite its strengths, this study has some limitations, including its cross-sectional nature, which prevents the establishment of causality and potential selection bias, given that patients were recruited from a tertiary care unit. Furthermore, longitudinal studies will be necessary to establish a causal relationship between DED and DR progression, to elucidate the long-term effects of targeted therapeutic interventions, and to determine the role of relevant biomarkers and advanced diagnostic characteristics in predicting the severity and course of DED in patients with diabetes. Overall, this study emphasizes the importance of early recognition and appropriate management in diabetic patients with DED to mitigate visual morbidity and improve quality of life. Prevention of ocular complications in such patients could lead to better clinical outcomes and increased patient satisfaction through a structured and evidence-based approach to managing DED and DR.

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