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A Clinical Study of Meibomian Gland Dysfunction in Patients with Diabetes: A Clinical Study

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Abstract
Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycemia, leading to numerous complications, including ocular issues. Meibomian Gland Dysfunction (MGD), a prevalent disorder affecting the lipid layer of the tear film, is increasingly recognized as a significant ocular complication in diabetic patients. MGD is marked by gland obstruction and altered secretions, causing dry eye symptoms and ocular surface disease. To determine the prevalence of MGD in patients with diabetes mellitus. To assess the severity and clinical presentation of MGD in diabetic patients. To explore potential pathophysiological mechanisms linking diabetes to MGD. This cross-sectional study included 200 participants (100 diabetic patients and 100 non-diabetic controls) recruited from a tertiary care hospital's ophthalmology outpatient department. Inclusion criteria encompassed confirmed diabetes mellitus in the diabetic group and age and gender-matched non-diabetic controls. Exclusion criteria included other ocular surface diseases, history of ocular surgery or trauma, medications affecting Meibomian gland function and autoimmune diseases. Data collected included demographic details, diabetes duration, HbA1c levels and BMI. MGD was assessed through clinical examinations, meibography and the Ocular Surface Disease Index (OSDI). Treatment outcomes for MGD in diabetic patients were evaluated after a 3-month follow-up. MGD was present in 62% of diabetic patients compared to 40% of non-diabetic patients ($p = 0.002$). Among diabetics with MGD, 29% had mild, 45% moderate and 26% severe MGD. A positive correlation $r = 0.58$, $p = 0.001$) between diabetes duration and MGD severity was noted. Diabetic patients had higher OSDI scores (34.7 vs. 28.3, $p = 0.004$). Warm compresses and lid hygiene showed significant improvement in MGD severity (45% and 40% improvement, respectively). Diabetic patients exhibit a higher prevalence and severity of MGD compared to non-diabetic individuals, with prolonged diabetes duration exacerbating the condition. Effective management includes warm compresses and lid hygiene. These findings underscore the necessity for regular screening and proactive management of MGD in diabetic patients to mitigate ocular discomfort and complications. Further research is needed to elucidate the underlying pathophysiological mechanisms and optimize treatment strategies.

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycemia due to defects in insulin secretion, insulin action, or both[1]. It is a leading cause of morbidity and mortality worldwide, affecting over 400 million people globally, a number projected to rise significantly over the next few decades[2]. The chronic nature of diabetes and its complications pose substantial health challenges, including neuropathy, nephropathy, retinopathy, cardiovascular diseases and impaired wound healing. Among these complications, ocular issues, particularly those affecting the anterior segment of the eye, are increasingly being recognized for their clinical significance[3].

One such ocular condition is Meibomian Gland Dysfunction (MGD), a prevalent disorder of the Meibomian glands which are responsible for secreting the lipid layer of the tear film. MGD is characterized by terminal duct obstruction and/or qualitative /quantitative changes in the glandular secretion, leading to alterations in the tear film and symptoms of ocular surface irritation. The dysfunction of these glands can cause dry eye symptoms, eyelid inflammation and more severe ocular surface disease. Given the essential role of the Meibomian glands in maintaining tear film stability, any dysfunction can have significant repercussions on ocular health[4,5].

Several studies have shown that the prevalence of MGD is higher in patients with diabetes compared to non-diabetic individuals. Research by Hom[5]. found that the prevalence of MGD in a diabetic cohort was significantly higher than in the non-diabetic control group . Another study by Caroline[6]. reported that the severity of MGD symptoms correlated with the duration of diabetes, suggesting a cumulative effect of chronic hyperglycemia on Meibomian gland function . These findings underscore the importance of recognizing MGD as a common complication in diabetic patients, warranting further exploration into its prevalence and clinical presentation.

The clinical presentation of MGD in diabetic patients can vary widely, ranging from mild discomfort to severe ocular surface disease. Symptoms may include dryness, irritation, burning, foreign body sensation and fluctuating vision. Objective findings often include lid margin abnormalities, altered meibum quality and reduced tear film stability. Studies have demonstrated that diabetic patients often present with more severe forms of MGD, characterized by greater gland dropout and more pronounced tear film instability . This severity may be attributed to the chronic inflammatory state and metabolic disturbances associated with diabetes[7,8].

Diabetes is linked to multiple glycated hemoglobin (MGD) through various pathophysiological mechanisms. Chronic hyperglycemia can induce low-grade inflammation, which can affect the Meibomian glands, leading to glandular dysfunction and obstruction. Diabetic neuropathy can impair the neural regulation of the Meibomian glands, causing decreased secretion and altered tear film lipid composition. Diabetes can cause microvascular changes, potentially causing ischemia and glandular dysfunction. Hormonal imbalances, such as insulin, can adversely affect lipid metabolism and glandular function. Furthermore, increased oxidative stress can damage cellular components of the Meibomian glands, leading to dysfunction and apoptosis. Understanding these mechanisms is crucial for developing targeted therapeutic strategies[9,10].

Recent research indicates a potential link between diabetes and Meibomian Gland Dysfunction (MGD), with an increased prevalence in diabetic patients. This study aims to understand the prevalence and severity of MGD in diabetic patients for enhanced clinical management, pathophysiological insights, public health implications and improved screening and diagnosis. Early identification and management of MGD can prevent further ocular surface damage and improve the quality of life for diabetic patients. Exploring the mechanisms linking diabetes to MGD can lead to targeted therapies that address the underlying causes of both conditions. The rising prevalence of diabetes worldwide could represent a significant public health issue, and identifying at-risk populations and implementing preventive measures can help healthcare systems allocate resources and reduce the burden of ocular complications in diabetic patients.

Aims and objectives:

- To determine the prevalence of Meibomian Gland Dysfunction in patients with diabetes mellitus.
- To assess the severity and clinical presentation of MGD in diabetic patients.
- To explore potential pathophysiological mechanisms linking diabetes to MGD.

MATERIALS AND METHODS

Study Design and Participants: This was a cross-sectional study conducted to assess the prevalence, severity, and clinical presentation of Meibomian Gland Dysfunction (MGD) in patients with diabetes mellitus, as well as to explore potential pathophysiological mechanisms linking diabetes to MGD. The study included two groups: diabetic patients (n = 100) and non-diabetic controls (n = 100). The participants were recruited from the ophthalmology outpatient department of a tertiary care hospital.

Inclusion and Exclusion Criteria
Inclusion Criteria:

- Diabetic patients with a confirmed diagnosis of diabetes mellitus.
- Non-diabetic controls matched for age and gender.
- Both male and female patients aged between 40 and 80 years.

Exclusion Criteria:

- Patients with other ocular surface diseases.
- Patients with a history of ocular surgery or trauma.
- Use of medications known to affect Meibomian gland function.
- Patients with autoimmune diseases.

Data Collection
Demographic and Clinical Data: Detailed demographic information, including age, gender, duration of diabetes, HbA1c levels and body mass index (BMI), was collected for all participants.

Assessment of MGD: The presence and severity of MGD were assessed using standardized clinical examination techniques:

- Meibomian gland expressibility was evaluated using digital pressure.
- Meibomian gland dropout was assessed via non-contact meibography.
- The severity of MGD was classified into mild, moderate and severe categories based on clinical criteria.

Ocular Surface Disease Index (OSDI): The OSDI questionnaire was administered to all participants to quantify the severity of ocular surface symptoms.

Clinical Examination Protocols
Meibomian Gland Evaluation:

- **Meibomian Gland Expressibility:** A standardized technique using digital pressure was employed to express the glands and evaluate the quality and quantity of the expressed meibum.
- **Meibography:** Non-contact meibography was performed using a specialized device to visualize the Meibomian glands and assess gland dropout.

Ocular Surface Disease Index (OSDI) Assessment:

- Participants were asked to complete the OSDI questionnaire, which consists of 12 questions related to the frequency of ocular symptoms, visual function, and environmental triggers. The total OSDI score was calculated to determine the severity of symptoms.

Treatment Protocols: Diabetic patients diagnosed with MGD were provided with the following treatment options and their outcomes were monitored:

- **Warm Compresses:** Patients were instructed to apply warm compresses to their eyelids twice daily.
- **Lid Hygiene:** Patients were taught proper lid hygiene techniques, including the use of lid scrubs.
- **Omega-3 Supplements:** Patients were advised to take omega-3 fatty acid supplements as per standard dosing guidelines.
- **Artificial Tears:** Patients were prescribed preservative -free artificial tears to use as needed for symptomatic relief.

The effectiveness of each treatment was evaluated after a follow-up period of 3 months and the improvement in MGD severity was documented.

Statistical Analysis: The collected data were analyzed using appropriate statistical methods:

- Descriptive statistics were used to summarize demographic and clinical characteristics.
- Chi-square tests were used to compare categorical variables (e.g., presence of MGD) between diabetic and non-diabetic groups.
- Independent t-tests were used to compare continuous variables (e.g., age, HbA1c, BMI) between groups.
- Pearson correlation analysis was conducted to explore the relationship between the duration of diabetes and MGD severity.
- Treatment outcomes were analyzed using paired t-tests to evaluate the effectiveness of different treatment modalities.

Ethical Considerations: The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants before inclusion in the study.

RESULTS AND DISCUSSIONS

(Table 1) provides a detailed comparison of demographic and clinical characteristics between diabetic and non-diabetic patients. The mean age of diabetic patients was 58.4 years, slightly higher than the 56.2 years observed in non-diabetic patients, but

Table 1: Demographic and Clinical Characteristics of Study Participants

Characteristic	Diabetic Patients (n = 100)	Non-Diabetic Patients (n = 100)	p-value
Age (years)	58.4±12.1	56.2±13.3	0.125
Gender (M/F)	54/46	52/48	0.732
Duration of Diabetes (years)	10.2±7.8	-	
HbA1c (%)	8.3±1.9	5.1±0.4	<0.001
BMI (kg/m²)	27.6±4.5	25.3±3.7	0.003

Table 2: Prevalence of MGD in Diabetic vs. Non-Diabetic Patients

MGD Status	Diabetic Patients (n = XX)	Non-Diabetic Patients (n = XX)	p-value
Present	62 (62%)	40 (40%)	0.002
Absent	38 (38%)	60 (60%)	0.002

Table 3: Severity of MGD in Diabetic Patients

Severity Level	Number of Diabetic Patients (n = 62)	Percentage
Mild	18	29
Moderate	28	45
Severe	16	26

Table 4: Correlation of MGD Severity with Duration of Diabetes

Duration of Diabetes (years)	Mean MGD Severity Score	Correlation Coefficient (r)	p-value
<5	1.8±0.7	0.58	0.001
5-10	2.4±0.8		
>10	3.1±1.0		

Table 5: Comparison of Ocular Surface Disease Index (OSDI) Scores between Diabetic and Non-Diabetic Patients

Group	Mean OSDI Score±SD	p-value
Diabetic Patients (n = 100)	34.7±13.5	0.004
Non-Diabetic Patients (n = 100)	28.3±12.9	0.004

Table 6: Treatment Outcomes for MGD in Diabetic Patients

Treatment Type	Number of Patients (n = 62)	Improvement in MGD Severity (%)	p-value
Warm Compresses	20	45	0.045
Lid Hygiene	18	40	0.050
Omega-3 Supplements	12	35	0.072
Artificial Tears	12	30	0.089

this difference was not statistically significant (p = 0.125). The gender distribution was fairly balanced in both groups, with 54 males and 46 females among diabetics and 52 males and 48 females among non-diabetics (p = 0.732). Diabetic patients had an average duration of diabetes of 10.2 years and significantly higher HbA1c levels (8.3%) compared to non-diabetics (5.1%), with a p-value of less than 0.001. Additionally, the body mass index (BMI) was significantly higher in diabetic patients (27.6 kg/m²) compared to non-diabetic patients (25.3 kg/m²) (p = 0.003).

(Table 2) illustrates the prevalence of Meibomian Gland Dysfunction (MGD) in diabetic and non-diabetic patients. MGD was present in 62% of diabetic patients compared to 40% of non-diabetic patients, a difference that was statistically significant with a p-value of 0.002. Conversely, 38% of diabetic patients did not have MGD, whereas 60% of non-diabetic patients were free from MGD, further highlighting the significant association between diabetes and the higher prevalence of MGD.

(Table 3) categorizes the severity of MGD among diabetic patients who were diagnosed with the condition. Out of the 62 diabetic patients with MGD, 29% had mild MGD, 45% had moderate MGD and 26% had severe MGD. This breakdown shows that moderate MGD was the most common severity level among the diabetic patients.

(Table 4) explores the correlation between the duration of diabetes and the severity of MGD. The data indicates that patients with less than 5 years of diabetes had a mean MGD severity score of 1.8, those with 5-10 years had a mean score of 2.4 and those with more than 10 years had a mean score of 3.1. There is a positive correlation (r = 0.58) between the duration of diabetes and the severity of MGD, with a statistically significant p-value of 0.001, suggesting that longer duration of diabetes is associated with increased MGD severity.

(Table 5) compares the Ocular Surface Disease Index (OSDI) scores between diabetic and non-diabetic patients. Diabetic patients had a higher mean OSDI score of 34.7, compared to 28.3 in non-diabetic patients. This difference is statistically significant, with a p-value of 0.004, indicating that diabetic patients experience more severe symptoms of ocular surface disease compared to non-diabetic patients.

(Table 6) presents the treatment outcomes for MGD in diabetic patients. Various treatments were assessed for their effectiveness in improving MGD severity. Warm compresses led to a 45% improvement, which was statistically significant with a p-value of 0.045. Lid hygiene showed a 40% improvement (p = 0.050), omega-3 supplements resulted in a 35% improvement (p = 0.072) and artificial tears showed a 30% improvement (p = 0.089). The data suggests that while all treatments provided some benefit, warm

compresses and lid hygiene had the most significant impact on improving MGD severity in diabetic patients.

This study aimed to determine the prevalence, severity and potential pathophysiological mechanisms of Meibomian Gland Dysfunction (MGD) in diabetic patients compared to non-diabetic controls. The results revealed a significant association between diabetes and increased prevalence and severity of MGD, contributing to the growing body of evidence suggesting a link between metabolic disorders and ocular surface diseases.

Prevalence of MGD: Our study found that 62% of diabetic patients had MGD, compared to 40% of non-diabetic patients ($p = 0.002$). This higher prevalence in diabetic patients aligns with the findings of previous studies. For instance, a systematic review[11]. also reported a higher prevalence of MGD in diabetic populations, suggesting that metabolic dysregulation in diabetes contributes to glandular dysfunction. However, the prevalence reported in our study is slightly higher, which could be attributed to differences in study populations or diagnostic criteria used for MGD.

Severity of MGD: Among diabetic patients with MGD, 45% had moderate MGD, which was the most common severity level. This distribution is consistent with findings by Yang[12]. who observed that diabetic patients often present with more severe forms of MGD compared to non-diabetics. The correlation between the duration of diabetes and the severity of MGD ($r = 0.58$, $p = 0.001$) further supports the notion that prolonged hyperglycemia exacerbates gland dysfunction. This correlation is consistent with previous studies that have highlighted the cumulative impact of chronic hyperglycemia on various ocular structures, including the meibomian glands[13].

Ocular Surface Disease Index (OSDI) Scores: Diabetic patients had significantly higher OSDI scores (34.7) compared to non-diabetic patients (28.3) ($p = 0.004$), indicating more severe ocular surface symptoms. This finding is in agreement with the work of Samrat[14]. who demonstrated that patients with diabetes often experience higher levels of ocular discomfort and dryness, likely due to the combined effects of MGD and other diabetic ocular complications such as diabetic retinopathy and neuropathy[15].

Pathophysiological Mechanisms: The pathophysiological mechanisms linking diabetes to MGD are complex and multi factorial. Hyperglycemia can lead to micro vascular damage, inflammation and oxidative stress, all of which may impair meibomian gland function. Additionally, the presence of advanced glycation end products (AGEs) in diabetic patients can alter the lipid composition of meibum, making it more viscous and prone to blockage[16]. These mechanisms were highlighted in studies by Habib[17], who suggested that chronic inflammation and oxidative damage play critical roles in the development of MGD in diabetic patients.

Treatment Outcomes: Regarding treatment, our study found that warm compresses and lid hygiene were the most effective interventions for MGD in diabetic patients, with improvements of 45% and 40%, respectively. These findings are consistent with those of Douglas[18], who reported significant benefits of warm compress therapy in managing MGD symptoms. The efficacy of omega-3 supplements and artificial tears, although beneficial, was less pronounced in our study, which may reflect variations in patient adherence or the severity of underlying gland dysfunction[19].

Comparison with Non-Diabetic Patients: When comparing diabetic to non-diabetic patients, it is evident that diabetes exacerbates both the prevalence and severity of MGD. Non-diabetic patients had a lower prevalence of MGD (40%) and generally milder symptoms, indicating that while MGD can occur in the absence of diabetes, the metabolic disturbances associated with diabetes significantly increase the risk and impact of this condition[20].

Limitations: The study's cross-sectional nature and potential selection bias make it difficult to draw causal inferences about the relationship between diabetes and Meibomian Gland Dysfunction (MGD). Additionally, the lack of longitudinal data, which does not follow patients over time, limits our understanding of how MGD progresses in diabetic patients and the long-term effectiveness of treatments.

CONCLUSIONS

The study reveals a higher prevalence of Meibomian Gland Dysfunction (MGD) in diabetic patients compared to non-diabetic individuals. Diabetic patients experience more severe forms of MGD and a higher incidence of ocular surface disease, with longer diabetes duration being associated with more severe MGD. Effective management strategies include warm compresses and lid hygiene, which improve MGD severity. However, omega-3 supplements and artificial tears have less impact. The findings suggest the need for regular screening and proactive management of MGD to reduce ocular discomfort and potential complications. Further research is needed to understand the pathophysiological mechanisms linking diabetes to MGD and develop optimized treatment protocols.

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