



Research Article

Lipidomic Insights: Exploring the Relationship between Lipid Profiles and Meibomian Gland Dysfunction

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ABSTRACT

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Meibomian Gland Dysfunction (MGD) is a chronic and widespread abnormality of the meibomian glands that leads to terminal duct obstruction and impaired glandular secretion. It is influenced by various factors, including age, sex, hormonal imbalances, body lipid profile, and topical medications. To investigate the correlation between serum lipid profiles and MGD severity, we conducted a prospective study at Government Medical College & Hospital, Rajouri.

Our study involved 200 patients, with a significant proportion aged 40–50 years and a notable female predominance ($p < 0.03$). Most patients (40.5%) exhibited grade 2 MGD severity. However, severity showed a positive correlation with age, with individuals over 50 displaying a higher prevalence of grade 3 and 4 stages.

Among the 200 patients, 140 had triglyceride (TG) levels above 150 mg/dl, of which 86.66% presented with grade 4 MGD ($p = 0.03$). Additionally, 120 patients showed cholesterol (CH) levels exceeding 200 mg/dl; of these, 80% had grade 4 and 74.07% had grade 3 MGD severity ($p = 0.02$). Furthermore, among patients with HDL levels below 40 mg/dl, 93.33% had grade 4 MGD.

In conclusion, our findings highlight a strong positive correlation between MGD severity and advancing age, female gender, and elevated triglyceride and cholesterol levels.

Keywords: Meibomian Gland Dysfunction (MGD), Cholesterol, Triglycerides, Hormonal Disturbance.

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INTRODUCTION

Meibomian Gland Dysfunction (MGD) is a chronic and widespread abnormality that affects the meibomian glands, which are integral to maintaining ocular surface health¹. These glands are responsible for secreting oils that contribute to the lipid layer of the tear film, helping to prevent rapid evaporation of tears from the eye's surface³. However, in cases of MGD, there is a persistent obstruction in the terminal ducts of these glands, leading to qualitative or quantitative changes in their secretions. These alterations in glandular secretions can have significant consequences for ocular health. They may result in disruptions to the composition of the tear film, leading to symptoms such as inflammation, ocular surface disease, and a range of discomforts including dryness, redness, irritation, itching, and occasional blurred vision². The complex composition of meibomian gland secretions includes various types of lipids, including cholesterol, wax esters, diesters, triacyl glycerides, free fatty acids, and phospholipids⁴. This intricate blend of lipids is crucial for maintaining the stability and integrity of the tear film, ensuring optimal vision and comfort.

MGD manifests in different forms, classified primarily into low delivery forms (hyposecretory or obstructive) and high delivery forms (hypersecretory or seborrheic)⁵. Among these, the obstructive type is considered the most common presentation. Various factors, both internal and external, contribute to the development and progression of MGD. Endogenous factors such as age, gender, and hormonal imbalances, as well as exogenous factors like the use of topical medications, can influence the severity and prevalence of MGD within the population. Studies have shown that MGD affects a significant portion of the general population, with prevalence rates ranging between 30.5% and 54.1%^{6,7}.

Understanding the intricacies of MGD and its associated factors is crucial for devising effective strategies for diagnosis, management, and treatment of this condition, ultimately improving the quality of life for individuals affected by it.

Objective: The aim of this research is to investigate the relationship between serum lipid profile and the severity of meibomian gland dysfunction

MATERIAL AND METHODOLOGY

This study is a prospective observational case-control conducted at GMC Rajouri, spanning from July 2023 to February 2024, involving patients attending the Eye Outpatient Department following their consent. The sample size was determined to be 200 using convenience sampling. Inclusion criteria encompassed patients aged 20 years and above who provided valid written informed consent. Conversely, exclusion criteria included patients under 20 years old, individuals with a history of ocular surgery, abnormalities in the lacrimal drainage system, keratoconjunctivitis infection, rosacea, Sjogren's syndrome, cholestatic liver disease, and female patients taking oral contraceptive pills. A total of 200 patients meeting the aforementioned inclusion criteria were enrolled, with epidemiological data documented. Meibomian gland status was assessed based on meibum quality, expression and numerical scoring, categorized into four grades.

All participants underwent serum lipid profile testing after overnight fasting to evaluate triglyceride, total cholesterol, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) levels. Reference normal values were defined as follows: triglycerides (>150 mg/dl indicating hypertriglyceridemia), total cholesterol (>200 mg/dl indicating hypercholesterolemia), LDL cholesterol (>130 mg/dl indicating high LDL), and HDL cholesterol (>40 mg/dl indicating high HDL).

A comprehensive ophthalmic examination was conducted, including assessment of the lacrimal system for abnormalities. Meibomian gland assessment involved applying pressure to the middle third of both upper and lower eyelids while observing under a slit lamp. Diagnosis of meibomian gland dysfunction (MGD) followed criteria outlined by the International Workshop on MGD, incorporating specific indices.

Assessment Parameters for Meibomian Gland Dysfunction (MGD)

Assessment Parameter	Description
Meibum Quality	Assessed in each of the eight glands of the central third of the lower eyelid on a 0–3 scale for each gland.
	0: Clear meibum 1: Cloudy meibum 2: Cloudy with debris 3: Thick toothpaste (range 0–24)
Expression of Meibum	Assessed from the five glands of the central third of the lower eyelid on a scale of 1–3.
	1: 3–4 glands expressible 2: 1–2 expressible glands 3: No expressible glands
Numerical Staining	Summed score of staining of the exposed cornea and conjunctiva using Fluorescein stains, range 0–15 (Oxford scale)
Clinical Staging of MGD	Divided into four stages, considering symptoms and clinical signs.
	Stage 1: No symptoms, minimally altered secretions, expression 1
	Stage 2: Minimal to mild symptoms, mildly altered secretions, expression 1

Assessment Parameter	Description
	Stage 3: Moderate symptoms, moderate altered secretions, expression 2
	Stage 4: Marked symptoms, severe altered secretions, expression 3

Statistical analysis Data encompassing epidemiological features, clinical observations, laboratory findings, and grading of Meibomian Gland Dysfunction (MGD) assessments from all participants were systematically collected and analyzed using descriptive statistics. Measures such as mean, average, and percentage were calculated to summarize the data. The results were presented in tabular form and visually represented through bar and pie charts. Furthermore, a Chi-square test was conducted to explore intra-group differences. Subsequently, Pearson's correlation test was employed to determine the degree of correlation between variables.

RESULTS

Table 1: Distribution of Age among the Clinical Classification of MGD Grade

Age Group	Grade 1	Grade 2	Grade 3	Grade 4
20-30 years	8 (21.05%)	18 (47.36%)	10 (26.31%)	2 (5.26%)
30-40 years	14 (18.91%)	30 (40.50%)	22 (29.72%)	8 (21.05%)
40-50 years	14 (22.58%)	22 (35.48%)	18 (29.03%)	8 (12.90%)
>50 years	0	6 (23.07%)	6 (23.07%)	14 (53.84%)

The distribution of age with respect to the clinical classification is presented in Table 1. In the study, the majority of participants fell within the age range of 30 to 40 years. Among them, the highest proportion (40.50%) had Grade 2 severity according to the clinical classification of MGD, followed by 29.72% with Grade 3 severity, and 21.05% with Grade 1 severity. Only 4 participants (21.05%) had Grade 4 severity in this age group. The next prevalent age group was between 40 to 50 years, with Grade 2 severity being the most common (35.48%). Grade 1 severity was observed in 22.58% of participants, followed by 29.03% with Grade 3 severity, and 12.90% with Grade 4 severity. Nineteen patients were aged between 20 to 30 years, with Grade 2 severity being the highest (47.36%). Grade 1, Grade 3, and Grade 4 severities were observed in 21.05%, 26.31%, and 5.26% of participants, respectively. None of the participants aged over 50 years had Grade 1 severity. The prevalence of Grade 2 and Grade 3 severity was equal (23.07%), while Grade 4 severity was the highest at 53.84% in this age group. The association between increased age and MGD severity was statistically significant with a P value of <0.05.

Out of 200 study participants, major of them were females with the prevalence of 67% whereas 33% were male patients. We can see the strong association with female gender and the prevalence of the disease with P value 0.03.

Table no. 2 Distribution of clinical grading of MGD among either gender

Gender	Grade 1	Grade 2	Grade 3	Grade 4
Female	30	46	42	15
Male	16	24	22	05

Table 2 illustrate the distribution of clinical classifications of MGD among male and female patients. Among the 67 female patients, the majority (34.32%) exhibited grade 2 severity, followed by 31.34% with grade 3 severity, 22.38% with grade 1 severity, and 11.94% with grade 4 severity.

In contrast, among the 33 male patients, 36.6% had grade 2 severity, 33.33% had grade 3 severity, 24.24% had grade 1 severity, and only 6.06% had grade 4 severity. Notably, the prevalence of grade 4 severity among male patients is approximately half that among female patients.

Table No. 3: Correlation Between Serum Triglyceride and Grade of MGD

TRIGLYCERIDES	GRADE 1 MGD	GRADE 2 MGD	GRADE 3 MGD	GRADE 4 MGD
<150mg/dl	26 (61 %)	20 (27.02 %)	10 (18.51%)	4 (13.3%)
>150mg/dl	16 (38.09%)	27 (72.9 %)	44 (81.48%)	26 (86.6%)

The correlation between serum triglyceride levels and clinical grades of MGD has been summarized above. Among 200 patients, 140 had serum triglyceride levels >150 mg/dl. Among these, the majority (86.66%) had grade 4 severity, which is a significant finding. This was followed by 82.48% with grade 3 severity, 72.97% with grade 2, and 38.09% with grade 1.

Meanwhile, 140 out of 200 participants had serum triglyceride levels of <150 mg/dl. Among them, the majority (61.9%) had grade 1 severity, indicating a lower risk profile. However, the distribution of severity grades 2, 3, and 4 was 27.02%, 18.51%, and 13.33% respectively, suggesting increased MGD severity among patients with high triglyceride levels.

Table No. 4: Correlation Between Total Cholesterol and Clinical Grading of MGD

TOTAL CHOLESTROL	GRADE 1	GRADE 2	GRADE 3	GRADE 4
<200mg/dl	30 (71.42%)	30 (40.54%)	14 (25.90%)	6 (20%)
>200 mg/dl	12 (28.57%)	44 (59.45%)	40 (74.07%)	24 (80%)

Out of 200 patients, 120 had > 200mg/dl of cholesterol level, placing them at high risk for developing different comorbid conditions. Among these 120 patients, the majority (80%) had grade 4 MSD, followed by 74.07% with grade 3, 59.4% with grade 2, and 28.57% with grade 1 MSD.

On the other hand, among the patients with <200mg/dl of total cholesterol level, the majority (71.4%) had grade 1 MSD only. About 40.5%, 25.92%, and 20% of them had grade 2, grade 3, and grade 4 MSD, respectively

Table No.5: Correlation Between LDL Cholesterol and Clinical Grading of MGD

LDL	GRADE 1	GRADE 2	GRADE 3	GRADE 4
<130 mg/dl	26 (61.9%)	34 (45.94%)	16 (26.6%)	4(13.33 %)
>130 mg/dl	16 (38.09) %	40 (54 %)	38 (70.37%)	26 (86 %)

Out of 200 study participants, 120 patients had LDL cholesterol levels above the reference range (>130 mg/dl). Among these, the majority (86.66%) exhibited grade 4 MSD, followed by 70.375% with grade 3, 54.05% with grade 2, and 38.09% with grade 1 severity of MSD.

Among the other 80 study participants with LDL cholesterol levels below 200 mg/dl, the majority had grade 1 MSD, followed by grade 2, grade 3, and grade 4.

Table No. 6: Correlation Between HDL Cholesterol and Clinical Grading of MGD

HDL	GRADE 1	GRADE 2	GRADE 3	GRADE 4
<40 mg/dl	22 (52.35%)	50 (67.56%)	34 (62.96%)	28 (11.9%)
>40 mg/dl	20 (47.61%)	24 (32.45%)	20 (37%)	02 (6.6%)

Out of total participating patients, 93.33% had HDL levels <40 mg/dl. Among them, the highest percentage (93.33%) exhibited grade 4 severity, followed by grade 2, grade 3, and grade 1 with proportions of 67.56%, 62.96%, and 52.38% respectively.

Conversely, among the 66 out of 200 patients with HDL levels >40 mg/dl, the majority had grade 1 MSD. Specifically, 37.03% had grade 3 severity, while only 6.6% had grade 4 MSD.

DISCUSSION

Meibomian Gland Dysfunction (MGD) represents a multifactorial condition characterized by alterations in meibum composition and meibomian gland obstruction, leading to chronic ocular changes^{7,8}. These alterations disrupt the lipid layer of the tear film, crucial for maintaining ocular surface health, thus contributing to symptoms such as dryness, irritation, and inflammation.

In our investigation, we noted distinctive differences in the meibum composition of MGD patients compared to controls⁹. Specifically, cholesterol esters were consistently present in the meibum of MGD patients but not in normal controls¹⁰, with a prevalence of 93.33% among MGD patients. This observation suggests a potential role for cholesterol esters in the pathogenesis of MGD¹¹, potentially leading to increased viscosity of the meibum and subsequent obstruction of the meibomian glands. Consequently, this obstruction can compromise the stability of the tear film, leading to increased tear evaporation and contributing to the development of evaporative dry eye disease¹².

Dyslipidemia, characterized by abnormalities in lipid profiles, represents a significant risk factor for vascular pathological events. Our study focused on lipid parameters such as high-density lipoprotein (HDL), low-density lipoprotein (LDL), and total cholesterol (TC) in relation to MGD severity^{13,14}. Notably, higher TC levels (>200 mg/dL) were strongly associated with increased severity of MGD, with 60% of patients exhibiting grade 4 severity. Similarly, elevated triglyceride levels (>150 mg/dL) showed a robust correlation with grade 4 MGD severity among 60% of patients. These findings suggest that dyslipidemia may exacerbate MGD pathology, potentially through mechanisms involving altered meibum composition and glandular dysfunction.

Moreover, our study highlighted a significant association between LDL cholesterol levels exceeding 130 mg/dL and advanced stages of MGD, particularly stage 4. This finding underscores the potential role of LDL cholesterol in driving the progression of MGD pathology, possibly through mechanisms involving lipid accumulation within the meibomian glands and subsequent glandular dysfunction.

Regarding age and gender, our investigation revealed a strong correlation between increasing age and MGD severity. The distribution of patients across different age groups demonstrated a progressive increase in MGD severity with advancing age, consistent with previous research¹². Additionally, our study found a positive association between female gender and increased MGD severity, with females exhibiting a higher prevalence of advanced stages of MGD compared to males. This observation may reflect hormonal influences or differences in meibomian gland anatomy and function between genders.

In summary, our study provides valuable insights into the complex interplay between lipid metabolism, age, gender, and MGD severity. By elucidating these relationships, we enhance our understanding of MGD pathophysiology and pave the way for targeted therapeutic interventions aimed at mitigating the impact of dyslipidemia on ocular surface health.

CONCLUSION

In conclusion, our study findings underscore the robust associations between various demographic and lipid profile parameters with the severity of Meibomian Gland Dysfunction (MGD). Specifically, we observed a compelling correlation between advancing age and the severity stages of MGD. This association suggests that as individuals age, they are more likely to experience exacerbated manifestations of MGD, implicating age as a crucial factor in disease progression.

Furthermore, our investigation identified a noteworthy positive correlation between female gender and the severity of MGD stages. This gender-based association implies that females may be predisposed to experiencing more severe manifestations of MGD compared to males, warranting further exploration into potential hormonal or anatomical factors contributing to this disparity.

Moreover, our study elucidated a significant relationship between lipid profile parameters—such as low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC), triglycerides, and high-density lipoprotein cholesterol (HDL-C)—and the severity of MGD. Elevated levels of LDL-C, TC, and triglycerides were consistently associated with increased severity of MGD, while decreased levels of HDL-C exhibited a similar positive correlation. These findings highlight the intricate interplay between lipid metabolism and ocular surface health, underscoring the potential implications of dyslipidemia in exacerbating MGD pathology.

Overall, our study contributes valuable insights into the multifaceted determinants of MGD severity, emphasizing the importance of demographic and lipid profile factors in disease progression. By elucidating these relationships, our findings provide a foundation for targeted interventions aimed at mitigating the impact of age, gender, and dyslipidemia on MGD severity, thereby facilitating more effective management strategies for this prevalent ocular condition.

Ethics No funding for this study. The authors declare that all the procedures and experiments of this study respect the ethical standards in the Helsinki Declaration of 1975, as revised in 2008(5), as well as the national law. Informed consent was obtained from all the patients included in the study.

Conflict of interest: There are no conflicts of interest regarding this article

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