RESEARCH PAPER

Accuracy and Clinical Utility of Infrared Meibography in the Evaluation of Dry Eye Disease

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ABSTRACT

Background: Dry Eye Disease is a common multi-factorial disorder affecting the tear film and ocular surface. Meibomian gland dysfunction is a major cause of Evaporative dry eye.
Conventional diagnostic tests such as Tear Break-Up Time and Schirmer's test evaluate tear function but do not provide information about gland structure. Infrared meibography is a non- invasive imaging technique that allows direct visualization of meibomian gland

AIM: To evaluate the accuracy and clinical utility of infrared meibography in the diagnosis and assessment of dry eye disease

Methods:A cross-sectional observational study was conducted on 80 patients presenting with symptoms of dry eye. All subjects underwent detailed ocular examination including Ocular Surface Disease Index, slit lamp examination, TBUT, Schirmer's test, and infrared meibography. Meibomian gland morphology was assessed and graded, and findings were correlated with conventional dry eye tests.

Result:A significant proportion of patients showed varying degrees of meibomian gland loss. A strong negative correlation was observed between gland loss and TBUT as well as Schirmer values. Increased gland dropout was associated with greater severity of dry eye symptoms.

Conclusion: Infrared meibography is a reliable, non-invasive, and clinically useful tool for evaluating meibomian gland structure. It enhances the diagnosis of dry eye disease when used alongside conventional tests and aids in early detection, treatment planning, and disease monitoring.

Key words: Dry eye disease Infrared meibography, meibomian gland dysfunction, OSDI, TBUT, Schirmer’s test
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INTRODUCTION

Dry Eye Disease is one of the most common ocular surface disorders encountered in clinical practice. It is a multi-factorial disease characterized by tear film instability, ocular discomfort, visual disturbance, and inflammation of the ocular surface. The condition not only affects visual performance but also significantly reduces the quality of life of affected individuals.

According to the TFOS DEWS II Report, dry eye disease is defined as a disorder of the tear film accompanied by symptoms in which tear film instability and hyperosmolarity, ocular surface inflammation, and neurosensory abnormalities play key roles. Dry eye is broadly classified into two main types: aqueous deficient dry eye and evaporate dry eye, with the latter being more prevalent.One of the major causes Evaporative dry eye is MGD. The Meibomian glands are specialized sebaceous glands located within the tarsal plates of the eyelids.

These glands secrete lipids that form the outermost layer of the tear film, which plays a crucial role in reducing tear evaporation and maintaining tear film stability. Dysfunction or structural loss of these glands leads to an inadequate lipid layer, resulting in increased tear evaporation and subsequent dry eye symptoms.

Traditional diagnostic methods for dry eye include (TBUT), Schirmer’s test, slit lamp examination, and symptom-based questionnaires such as the (OSDI). While these tests provide valuable information about tear film function and patient symptoms, they have certain limitations. These include variability in results, subjectivity, and inability to directly assess the structure of the Meibomian glands.In recent years, infrared meibography has emerged as an advanced, non-invasive imaging technique that allows direct visualization of the morphology of meibomian glands. It uses infrared illumination to capture detailed images of the glands, enabling the assessment of gland dropout, shortening, distortion, and overall gland architecture. This technique provides important structural information that complements the functional data obtained from conventional tests.

Several studies have demonstrated a strong correlation between meibomian gland loss and dry eye severity. Infrared meibography has shown promising results in

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detecting early gland changes even before the onset of significant clinical symptoms. This makes it a valuable tool not only for diagnosis but also for monitoring disease progression and guiding treatment strategies.Despite its growing use, there is still a need to evaluate the accuracy and clinical utility of infrared meibography in comparison with conventional diagnostic methods. Understanding its role in routine clinical practice can help improve the diagnosis and management of dry eye disease.This imaging technique utilizes infrared illumination to enhance contrast between the glands and surrounding tissues, enabling clinicians to assess features such as gland dropout, shortening, tortuosity,and distortion. Quantitative grading systems derived

from meibography images have been proposed to standardize assessment and improve reproducibility. Importantly, these structural findings may precede clinical symptoms, suggesting a potential role for meibography in early detection and preventive care.Despite these advantages, the integration of infrared meibography into routine practice is still evolving.

Variability in image acquisition,interpretation,and grading criteria-can Influence diagnostic consistency. Additionally, the relationship between meibographic findings and clinical parameters

such as symptom severity, tear film stability, and ocular surface damage—remains an area of ongoing research. Some studies have reported significant correlations, while others highlight discrepancies, underscoring the need for further systematic evaluation.

Another important consideration is the clinical utility of meibography in guiding treatment decisions and monitoring therapeutic response. With the advent of targeted therapies for MGD, including thermal pulsation, intense pulsed light therapy, and lipid-based tear supplements, there is a need for reliable tools that can objectively assess treatment efficacy. Infrared meibography may offer a means to track structural changes over time, thereby providing insight into disease progression and the impact of interventions.

Role of Schirmer's Test in Dry Eye

The Schirmer’s test is one of the most commonly used diagnostic methods for assessing aqueous tear production. It helps in identifying aqueous deficient dry eye.

Procedure: A sterile filter paper strip is placed in the lower fornix of the eye, usually at the junction of the middle and lateral third of the eyelid. The patient is asked to close the eyes, and the amount of wetting is measured after 5 minutes.

Interpretation:

10 mm → Normal tear production

5–10 mm → Mild to moderate dry eye

<5 mm → Severe dry eye

The Schirmer's test provides quantitative information about tear secretion. However, it has certain limitations such as variability, reflex tearing, and lack of information about tear film quality or meibomian gland structure.

Role of Infrared Meibography in Dry Eye

In contrast to functional tests like Schirmer's, infrared meibography provides a structural assessment of the meibomian glands.Infrared meibography is a non-invasive imaging technique that uses infrared light to visualize the morphology of meibomian glands. It allows clinicians to observe gland architecture, including:

- Gland dropout (loss)
- Shortening of glands
- Distortion or tortuosity

This technique plays a vital role in detecting meibomian gland dysfunction, which is a major cause of Evaporative dry eye.

Clinical Importance:

Infrared meibography helps in Early diagnosis of dry eye Differentiate between types of dry eye-treatment planning (e.g., warm compress, gland expression) Monitoring disease progression

Therefore, the present study was undertaken to evaluate the role of infrared meibography in correlation with OSDI, TBUT, and Schirmer test in patients with dry eye disease.

MATERIAL AND METHODS

STUDY DESIGN: Cross- Sectional observational study STUDY SETTING: Mathura Das Mathur Hospital Jodhpur SAMPLE SIZE: 60-80 Patient

STUDY DURATION: 8 months

INFRARED MEIBOGRAPHY DEVICE:Non-contact infrared imaging system

- Used to visualize meibomian gland morphology and dropout.
- Grading according to test

Role of Infrared Meibography in Dry Eye

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Clinical Importance:

Infrared meibography helps in Early diagnosis of dry eye Differentiation between types of dry eye Treatment planning (e.g., warm compress, gland expression)Each patient underwent the following tests: STEPS USEDPatient consent taken thenOSDI Questionnaire

The OSDI consists of 12 items, categorized into three sub-scales:

1. Ocular Symptoms
2. Vision-Related Function
3. Environmental Trigger

The final OSDI score is calculated using the following formula:

OSDI = [Sum of scores]25 / Number of questions answered

[1] Eyelid eversion

[3][3] Image capture of meibomian gland Schirmer Test

PROCEDURE

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MEIBOGRAPHY: Infrared meibography was performed using a non-contact technique to evaluate the morphology of meibomian glands. Both upper and lower lids were examined. The degree of gland loss was graded from GRADE 0 to GRADE 4 based of gland dropout.

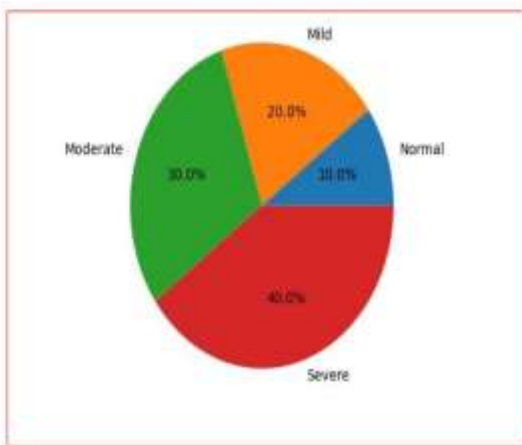
RESULTS

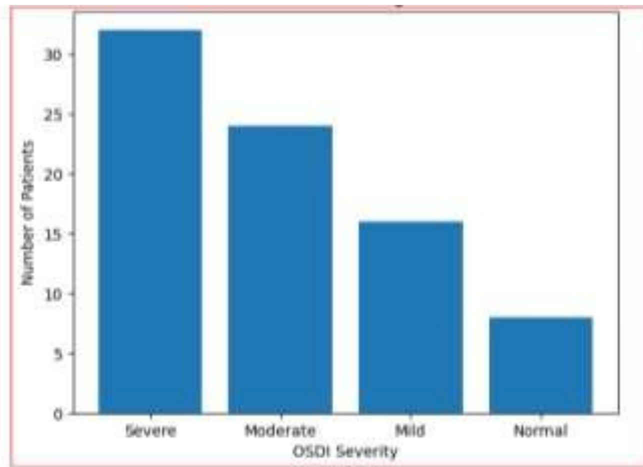
A total of 80 patients presenting with symptoms of dry eye were included in this study.

All subjects were assessed using OSDI, TBUT, Schirmer's test, slit lamp examination, and infrared meibography.

5.1 OSDI DISTRIBUTION

Severity	**No. of Patients**	**Percentage [%]**
Normal	8	10%
Mild	16	20%
Moderate	24	30%
Severe	32	40%
Total	**80**	**100%**



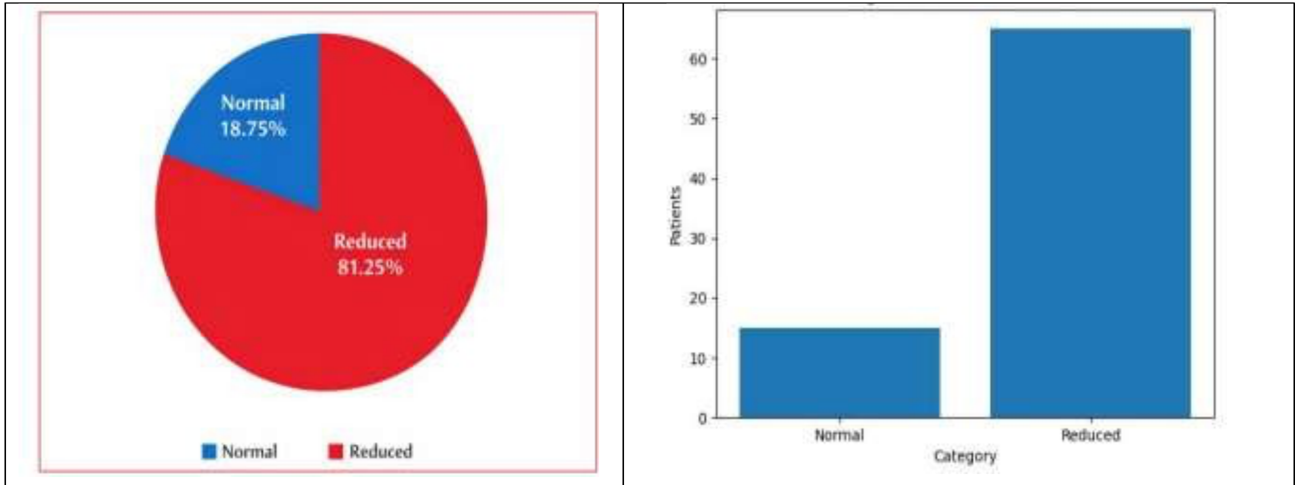


Interpretation:

A considerable proportion of patients demonstrated moderate to severe symptoms, indicating that dry eye Symptoms were prominent in the majority of cases

Table 5.2: TBUT Distribution

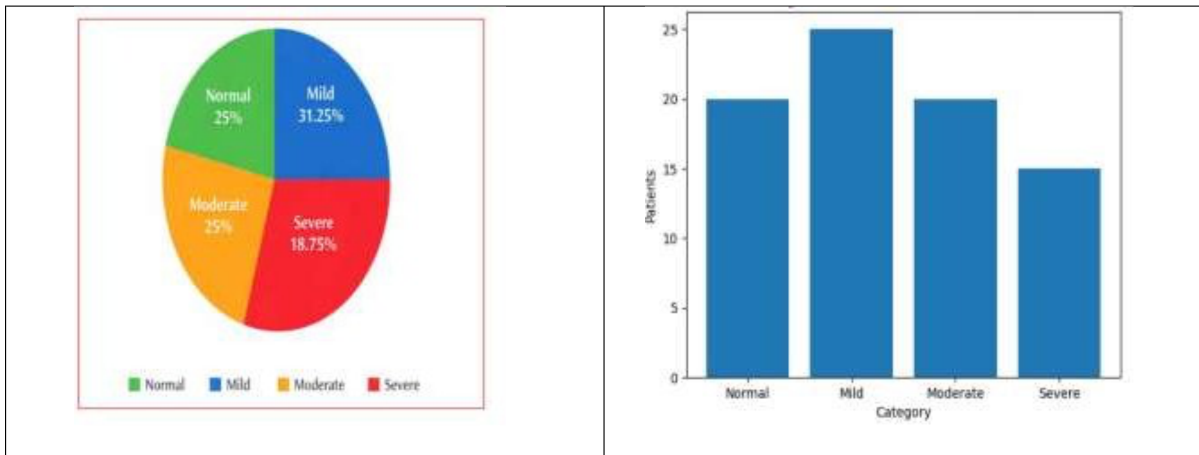
Category	**No. of Patients**	**Percentage**
Normal	15	18.75%
Reduced	65	81.75%
Total	**80**	**100%**



Interpretation:
The predominance of reduced TBUT reflects significant tear film instability,suggesting that Evaporative mechanisms play a major role.

Table 5.3 : Schirmer test

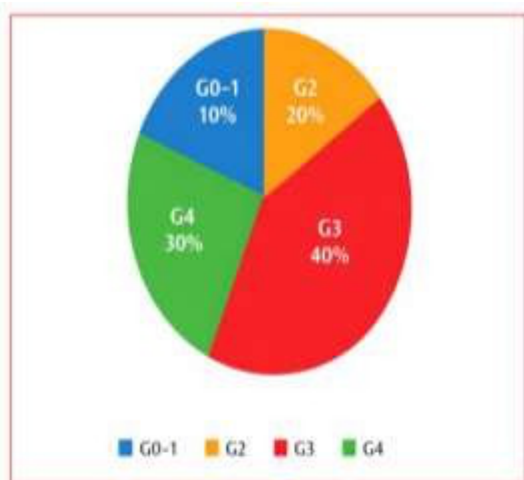
Category	No. of Patient	Percentage (%)
Normal	20	25%
Mild	25	31.25%
Moderate	20	25%
Severe	15	18.75%
Total	**80**	**100%**

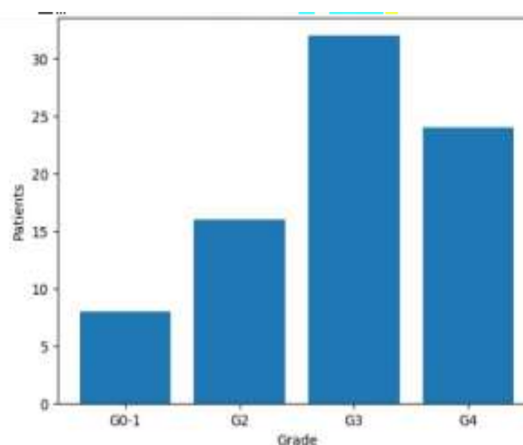


Interpretation:
These findings indicate that aqueous deficiency was present but mostly in mild to moderate form, and not the sole contributor to the disease.

Table 5.4: Meibography Distribution

Grade	No. of Patients	Percentage%
G0-1	8	10%
G2	16	20%
G3	32	40%
G4	24	30%
Total	**80**	**100%**





Interpretation:
The high proportion of patients with advanced gland loss (Grade 3–4) indicates that structural damage to the meibomian glands is a major factor in dry eye disease

DISCUSSION

Dry eye disease (DED) is a multi-factorial disorder involving tear film instability, ocular surface inflammation, and neurosensory abnormalities. In the present study, the role of infrared meibography in the evaluation of dry eye disease was assessed and compared with conventional diagnostic methods such as OSDI, TBUT, and Schirmer test.

In this study, the majority of patients showed moderate to severe OSDI scores (70%), indicating a high prevalence of significant symptoms. These findings are consistent with previous studies, which have reported that patient-reported symptoms are often substantial in dry eye disease and can significantly affect quality of life.

Tear film stability, assessed by TBUT, was found to be reduced in 81.25% of patients, suggesting with earlier reports that highlight meibomian gland dysfunction (MGD) as a leading cause of tear film instability.

The Schirmer test results demonstrated that mild to moderate aqueous deficiency was present in a proportion of patients. However, the variation in Schirmer values compared to TBUT findings suggests that aqueous deficiency alone may not fully explain the severity of dry eye symptoms. This supports the concept that dry eye disease often has a mixed etiology.Infrared meibography revealed that 70% of patients had Grade 2–3 gland loss, indicating moderate meibomian gland dysfunction. These findings are in agreement with previous literature, which emphasizes that structural changes in meibomian glands play a crucial role in the pathogenesis of Evaporative dry eye. The higher prevalence of gland loss observed in this study further supports the importance of evaluating gland morphology.

A significant observation in this study is the correlation between meibography findings and other clinical parameters. Patients with higher grades of gland loss tended to have higher OSDI scores and reduced TBUT, indicating that structural gland damage is associated with both increased symptom severity and tear film instability. This finding reinforces the clinical utility of meibography as an objective tool in dry eye assessment.

Furthermore, infrared meibography proved to be a non-invasive, quick, and patient-friendly technique, allowing direct visualization of gland architecture. Unlike traditional tests, which may show variability and limited correlation, meibography provides a more consistent and reliable assessment of underlying pathology,

Overall, the findings of this study highlight that while conventional tests such as OSDI, TBUT, and Schirmer are useful, they have certain limitations when used independently. Infrared meibography complements these tests by providing structural evaluation, thereby improving diagnostic accuracy. A strong negative correlation was observed between meibomian gland loss and Tear Break-Up Time, as well as Schirmer's test values. This suggests that as gland dropout increases, tear film stability and tear production decrease, leading to worsening of dry eye symptoms. These findings are in agreement with previous studies, which have highlighted that structural changes in the meibomian glands are closely associated with functional tear film abnormalities.

Conventional diagnostic tests such as TBUT and Schirmer's test provide useful information regarding tear film function; however, they do not offer direct visualization of gland structure. In contrast, infrared meibography allows detailed assessment of meibomian gland morphology, including gland dropout, shortening, and distortion. Therefore, it serves as a valuable adjunct to traditional diagnostic methods.

Another important observation of this study is that patients with higher grades of gland
loss reported more severe symptoms of dry eye. This indicates a positive association between gland morphology and clinical symptomatology. Infrared meibography also proved to be a non- invasive, rapid,

and patient-friendly technique, making it suitable for routine clinical use.

FINAL CONCLUSION

The present study evaluated the accuracy and clinical utility of infrared meibography in the assessment of dry eye disease and its correlation with conventional diagnostic tests such as OSDI, TBUT, and Schirmer test.The findings revealed that a majority of patients had moderate to severe symptoms, along with reduced tear film stability, indicating a high prevalence of dry eye diseasein the study population. Meibography demonstrated that most patients had moderate meibomian gland loss (Grade 2–3), highlighting the significant role of meibomian gland dysfunction in the pathogenesis of dry eye.A positive correlation was observed between meibography findings and clinical parameters, particularly TBUT and OSDI scores, suggesting that structural glandchanges are associated with increased symptom severity and tear film instability.Infrared meibography proved to be a non-invasive, reliable, and effective diagnostic tool, providing direct visualization of meibomian gland morphology. It complements conventional tests and enhances the overall accuracy of dry eye evaluation.In conclusion, infrared meibography has significant clinical utility and should be considered an important component in the routine assessment and management of patients with dry eye disease.Based on the findings of the study, the following conclusions can be drawn:Infrared meibography is a reliable and non-invasive diagnostic tool for evaluating meibomian gland morphology.There is a significant correlation between meibomian gland loss and conventional dry eye tests such as TBUT and Schirmer test.Increased meibomian gland dropout is associated with greater severity of dry eye.Infrared meibography helps in the early detection of meibomian gland dysfunction, even before severe clinical symptoms appear the technique has high clinical utility as it aids in diagnosis, treatment planning, and monitoring of dry eye patients.

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