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Original Research Article

A CASE-CONTROL STUDY: IMPACT OF PTERYGIUM ON TEAR FILM STABILITY AND MEIBOMIAN GLANDS

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ABSTRACT

Background: Pterygium is a common degenerative disorder of the ocular surface characterized by fibrovascular proliferation of conjunctival tissue extending onto the cornea. It is frequently associated with dry eye disease and ocular discomfort, which can adversely affect visual function and quality of life. While the aqueous component of the tear film has been traditionally emphasized in pterygium-related dry eye, recent attention has turned to the role of meibomian gland dysfunction (MGD) as a contributor to evaporative dry eye. This study aimed to assess, compare, and correlate tear film stability, meibomian gland function, and ocular surface symptoms between eyes with pterygium and their contralateral normal eyes in patients with unilateral disease, thereby highlighting the need for a comprehensive dry eye evaluation in this population. **Materials and Methods:** A hospital-based case-control study was conducted on 47 patients diagnosed with unilateral primary pterygium. The eye with pterygium was designated as the case eye, while the contralateral normal eye served as the control. Clinical assessment included the Ocular Surface Disease Index (OSDI) questionnaire to quantify symptom severity, Schirmer's I test to evaluate basal and reflex tear secretion, Tear Film Break-Up Time (TBUT) for tear stability, and Tear Meniscus Height (TMH) for tear volume. Meibomian gland function was evaluated through lid margin abnormality scoring, expressibility grading, and meibum quality analysis. Descriptive statistics were calculated for all variables. Chi-square test and analysis of variance (ANOVA) were used for comparisons between case and control eyes, with $p < 0.05$ considered statistically significant. **Result:** Eyes with pterygium showed significantly lower mean values for Schirmer's I test (10.77 ± 3.25 mm), TBUT (10.04 ± 3.72 sec), and TMH (0.172 ± 0.06 mm) compared to controls (15.09 ± 3.13 mm, 14.15 ± 3.56 sec, and 0.326 ± 0.06 mm respectively; $p < 0.001$ for all). Meibum quality scores were significantly higher in the pterygium group (1.13 ± 0.82 vs. 0.62 ± 0.57, $p < 0.001$), indicating poorer gland function. OSDI scores were positively correlated with both meibomian gland expressibility ($r = 0.635$) and meibum score ($r = 0.784$), highlighting the clinical impact of MGD in these patients. **Conclusion:** This study demonstrates a strong association between pterygium and ocular surface abnormalities involving both the aqueous and lipid layers of the tear film. The presence of significant MGD and unstable tear film in affected eyes underscores the importance of routine screening for evaporative dry eye in all patients with pterygium, regardless of symptom severity. Clinical management should not only target the pterygium itself but also incorporate preoperative or adjunctive treatment of MGD using lipid-enhancing artificial tears, warm compress therapy, and omega-3 fatty acid supplementation to improve ocular surface integrity and potentially enhance surgical outcomes and patient comfort.

INTRODUCTION

Pterygium is a common degenerative fibrovascular disorder of the ocular surface that can lead to ocular discomfort, corneal irregularities, and cosmetic concerns, potentially impairing visual acuity and reducing patients' quality of life.[1–3] Its global prevalence is estimated to range from 10.2% to 12%, with significantly higher rates observed in tropical and equatorial regions due to increased ultraviolet (UV) exposure.

Multiple risk factors have been associated with pterygium development, including geographic latitude, rural residence, advancing age, race, male sex, chronic sun exposure, and long-term ocular irritation and inflammation.[4,5] In recent years, a growing body of evidence has suggested that pterygium may also contribute to ocular surface instability, leading to symptoms such as foreign body sensation, irritation, and dry eye disease (DED).

The Tear Film and Ocular Surface Society (TFOS) DEWS II defines dry eye as a multifactorial disease of the tears and ocular surface characterized by a loss of homeostasis of the tear film, accompanied by ocular symptoms such as discomfort, fluctuating vision, tear film instability, and hyperosmolarity. If left unaddressed, dry eye can result in inflammation and damage to the ocular surface epithelium.

Standard diagnostic tests for dry eye, including the Tear Film Break-Up Time (TBUT) and Schirmer's I test, focus primarily on the aqueous-deficient subtype. However, the evaporative component of dry eye—largely attributable to Meibomian Gland Dysfunction (MGD)—is often underdiagnosed and undertreated.

MGD is a chronic, diffuse disorder of the meibomian glands, characterized by abnormal glandular secretion in terms of quality and/or quantity. The meibomian glands are specialized sebaceous glands located within the eyelids that secrete meibum, the lipid layer of the tear film. This lipid layer reduces tear evaporation and maintains tear film stability.[6,7] Dysfunction of these glands contributes to evaporative dry eye, posterior blepharitis, and ocular surface inflammation.[8]

In pterygium, pathological changes in the conjunctiva, cornea, and eyelids can disrupt tear film homeostasis. The mechanical traction exerted by the fibrovascular tissue may alter eyelid dynamics and blinking patterns, contributing to increased tear evaporation.[9] Although the role of tear film disruption in pterygium has been described, the specific contribution of MGD remains poorly characterized.

Previous histological studies, such as those by Li et al., have demonstrated reduced goblet cell density in pterygium-affected eyes, contributing to mucin deficiency and unstable tear films.[10] Conversely, Turkyilmaz et al. reported a significant post-surgical increase in goblet cell density one month after excision, suggesting a reversible component of mucin deficiency and ocular surface restoration following removal of the lesion.[11]

Despite the known association between pterygium and dry eye, few studies have comprehensively evaluated the combined impact on both aqueous and lipid tear components. This gap highlights the need for targeted research into the role of meibomian gland dysfunction in these patients.

Understanding how pterygium affects both tear volume and meibomian gland function can aid in developing comprehensive management strategies that extend beyond surgical excision alone.

Furthermore, a deeper comprehension of the pathophysiological mechanisms linked to pterygium, the morphological changes on the ocular surface, and the functional impact may help to shape targeted strategies and more effective therapeutic approaches for this widespread ocular condition.

In this study, we aim to evaluate, compare, and correlate ocular discomfort, tear film parameters, and meibomian gland abnormalities in eyes with pterygium, using the contralateral unaffected eyes as internal controls.

Aim: To assess impact of pterygium on tear film stability and meibomian glands.

Objectives

- To identify and compare meibomian gland abnormalities, tear film changes and ocular discomfort in eyes with pterygium to that of normal eye.
- To determine the correlation of meibomian gland and tear film changes with pterygium.

MATERIALS AND METHODS

After obtaining ethical committee clearance this study titled 'A Case-Control study: Impact of pterygium on tear film stability and meibomian glands' was conducted in the Department of Ophthalmology, Katihar Medical College and Hospital, Katihar between August 2022 to February 2024.

Study Design: Case-control study.

Cases: Patients with Unilateral Pterygium.

Controls: Normal eye of same patients with Unilateral Pterygium.

While using the contralateral (fellow) eye of the same patient as a control is practical and minimizes individual variability in systemic, genetic, and lifestyle factors, it is not without limitations. Both eyes are subjected to the same systemic influences and environmental exposures—such as UV radiation, wind, dust, and inflammatory cytokines—which can affect tear film stability and meibomian gland function bilaterally, even if pterygium is clinically unilateral. This design may thus underestimate the degree of difference between affected and unaffected eyes. Subclinical changes in the fellow eye may lead to conservative estimates of the impact of pterygium on ocular surface health. Recognizing this limitation is essential when interpreting the results, and future

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studies may consider using an independent control group for more definitive comparisons.
Sample size and its calculation: Based on data from the article "Meibomian Gland Dysfunction Correlates to Tear Film Instability and Ocular Discomfort in Patients with Pterygium" published in scientific reports by Huping et al, which found significant correlations between the variables, a sample size of 50 was obtained.
The parameter "Expressibility score" with mean and SD of 2.35+/- 0.80 and 2.83+/- 0.86 for controls and cases was used in nMaster2.0.
A sample size of 47 was obtained for each group with Alpha-5% , Beta-20% ,Power-80%

Inclusion criteria
- Individuals who have a primary pterygium in one eye.
- Willingness to participate in the study.

Exclusion criteria
- Individuals with scar or disease of the cornea.
- Contact lens use in last 3 months.
- Cicatrization of the ocular surface illness.
- Ocular allergy symptoms (e.g., itching, redness, tearing, or discharge in the past 4 weeks).
- Any eye injuries or previous ocular surgeries..
- Infectious disorders of the cornea and conjunctiva.
- Use of any topical eye medicines within the previous six months.
- Sjogren's disease, diabetes mellitus, dyslipidaemia, and acne rosacea are systemic disorders that have an impact on tear production and function.

Techniques and parameters used: All study participants provided written informed consent in both English and the local language prior to enrolment. Ocular discomfort was assessed using the Ocular Surface Disease Index (OSDI) questionnaire.

I. Assessment of Pterygium

Assessment was performed using slit-lamp bio microscopy.

A) Staging of Pterygium
- Resting Stage: Thin, flat tissue with mild or no hyperaemia; non-regressing.
- Progressive Stage: Thick, hypertrophic, hyperaemic tissue with dilated vessels; underlying sclera not clearly visible. Severe cases may involve encroachment of the pterygium head into the pupillary zone.

B) Grading by Pterygium Size
- Grade 1: <¼ of corneal diameter covered
- Grade 2: ¼ to ½ of corneal diameter covered
- Grade 3: ½ to ¾ of corneal diameter covered
- Grade 4: >¾ of corneal diameter covered, sparing pupillary centre
- Grade 5: Involving pupillary area, but not crossing it
- Grade 6: Extending across the pupillary axis

C) Grading by Transparency
- Grade 1: Superficial vessels and underlying sclera clearly visible
- Grade 2: Partial obscuration of vessels and sclera
- Grade 3: Complete obscuration; vessels and underlying sclera not visible through the tissue

II. Assessment of tear film instability parameters

A) Schirmer's I Test: Schirmer's I test was performed without topical anaesthesia, in accordance with the TFOS DEWS II diagnostic protocol for assessing aqueous tear production. A sterilized Schirmer strip (5×35 mm) was placed at the junction of the lateral one-third and medial two-thirds of the lower eyelid fornix.12 The patient was instructed to keep their eyes gently closed during the test, and the amount of wetting was recorded after 5 minutes. A value greater than 10 mm was considered normal.
To reduce variability, all measurements were performed between 9–11 AM under standardized room conditions by a single examiner.

B) Tear Break-Up Time (TBUT): TBUT was measured according to DEWS II guidelines to assess tear film stability. A fluorescein-impregnated strip moistened with non-preserved saline was applied to the inferior tear meniscus. The patient was asked to blink three times and then keep their eyes open while looking straight ahead. The time between the last blink and the appearance of the first dry spot was observed under a slit lamp using a cobalt blue filter. The mean of three consecutive readings was taken. TBUT <10 seconds was considered abnormal.
All assessments were conducted at a fixed time by the same examiner to maintain consistency and reduce diurnal variability.

C) Tear Meniscus Height (TMH): TMH was evaluated under slit-lamp bio microscopy using diffuse illumination and low magnification. The lower tear meniscus was examined at the central lower eyelid margin, with care taken to avoid reflex tearing. According to TFOS DEWS II diagnostic guidelines, a TMH of greater than 0.3 mm was considered normal, while values $\leq$ 0.2 mm were suggestive of aqueous-deficient dry eye.[12]

III. Assessment of Meibomian Gland Parameters

A) Lid Margin Abnormalities

Lid margins were examined under slit-lamp bio microscopy. Four specific abnormalities were evaluated:
- Vascular engorgement
- Plugged meibomian gland orifices
- Anterior or posterior displacement of the mucocutaneous junction
- Irregularity of the lid margin

Each abnormality was graded as:
- 0 – Absent
- 1 – Present

A score of 1 was assigned for each abnormality present, yielding a total lid margin abnormality score ranging from 0 to 4.

B) Meibomian Gland Expressibility and Meibum Quality: Evaluation was performed under diffuse illumination using slit-lamp biomicroscopy. The central five meibomian glands of the upper and lower eyelids were digitally pressed to assess expressibility and lipid quality.

i) Meibomian Gland Expressibility Score:

Graded as follows:

- Score 0: Secretions expressed from all 5 glands
- Score 1: Secretions expressed from 3–4 glands
- Score 2: Secretions expressed from 1–2 glands
- Score 3: No secretion expressed from any gland

Expressibility was assessed separately in both eyelids, with a combined score range of 0 to 6 per eye.

ii) Meibum Quality (Meibum Score):

The quality of expressed meibum was graded based on color and consistency:

- Score 0: Clear or slightly yellow fluid
- Score 1: Creamy yellow fluid
- Score 2: Granular fluid with white and/or yellow particles
- Score 3: Thick, toothpaste-like secretion

Meibum quality was similarly assessed for both eyelids, with a total score range of 0 to 6 per eye.

To reduce subjectivity and enhance consistency, all meibomian gland evaluations were conducted by a single experienced examiner who was masked to the eye being assessed (i.e., case or control). A standardized pressure was applied across all evaluations using consistent technique under the same slit-lamp settings. Although inter-observer agreement was not evaluated, observer masking and uniform methodology were implemented to minimize grading bias and improve reliability of the subjective assessments.

RESULTS

Statistical analysis -Data was entered into a Microsoft Excel spreadsheet, then was analysed using IBM SPSS (version 27.0; SPSS Inc., Chicago, IL, USA). To depict the qualitative data, proportions and percentages were employed. For quantitative data, the mean standard deviation was employed. Later on, relevant significance tests were used. P value < 0.05 was regarded as statistically significant.

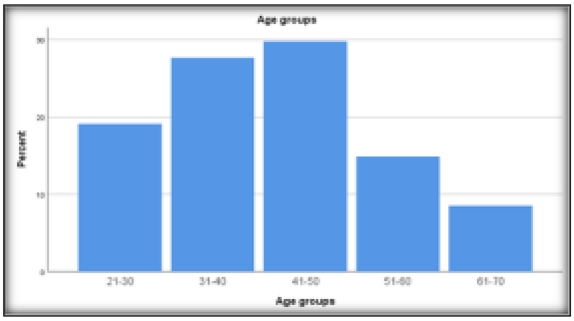


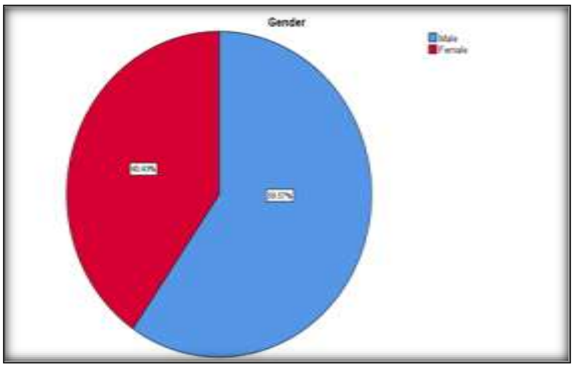
Table 1: Age distribution of pterygium patients

		Frequency	Valid %	Cumulative %
Valid	21-30	9	19.1	19.1
	31-40	13	27.7	46.8
	41-50	14	29.8	76.6
	51-60	7	14.9	91.5
	61-70	4	8.5	100.0
	Total	47	100.0	

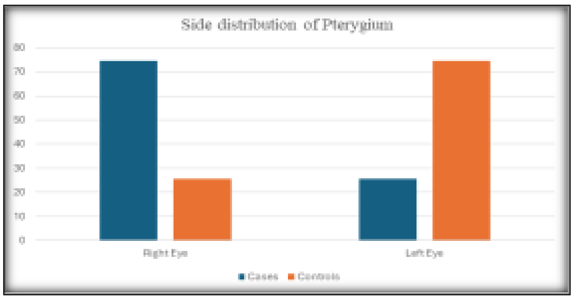
Age Group Distribution: The majority of patients with pterygium fall within the 31-50 age range (57.5%), indicating that pterygium is most prevalent among middle-aged individuals. The least affected group is those aged 61-70, making up only 8.5% of the cases.

Table 2: Sex distribution of pterygium patients

		Frequency	%
Valid	Male	28	59.6
	Female	19	40.4
	Total	47	100.0



Sex Distribution: Males (59.6%) are more frequently affected by pterygium than females (40.4%), suggesting a possible gender predisposition towards the condition.



Distribution of pterygium side: In cases, the right eye is more commonly affected (74.5%) compared to the left eye (25.5%). Conversely, in controls, the left eye (74.5%) is more commonly involved. This could indicate a unilateral dominance in the manifestation of pterygium in patients.

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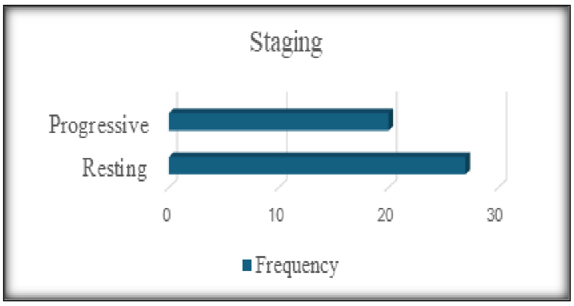
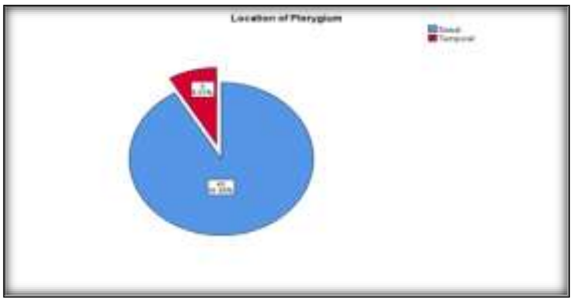
Table 3: distribution of side in pterygium

Eye	Category			
	Cases	%	Controls	%
Right	35	74.50	12	25.50
Left	12	25.50	35	74.50
Total	47	100	47	100

Table 4: Distribution of pterygium stages

Pterygium Stage	Frequency	%
Resting	27	57.4
Progressive	20	42.6
Total	47	100





Pterygium Stage: The majority of cases are in the resting stage (57.4%), while the remaining are in the progressive stage (42.6%). This indicates that most patients are in a less active phase of the disease.

Pterygium Location: Most pterygium cases are nasal (91.5%), with a small fraction being temporal (8.5%). This suggests a significant predisposition for pterygium to develop on the nasal side of the eye.

Table 5: Pterygium location distribution

Location	Frequency	%
Nasal	43	91.5
Temporal	4	8.5
Total	47	100

Table 6: Schirmer's-1 test results & comparison between cases and controls

Schimer-1 test		Category		Total	Chi-square Value	P value
		Cases	Controls			
Abnormal (<10)	Count	13	0	13	15.09	<0.001**
	% within category	27.65%	0%			
Normal (>10)	Count	34	47	81		
	% within category	72.34%	100%			
Total	Count	47	47	94		
	% within category	100%	100%			

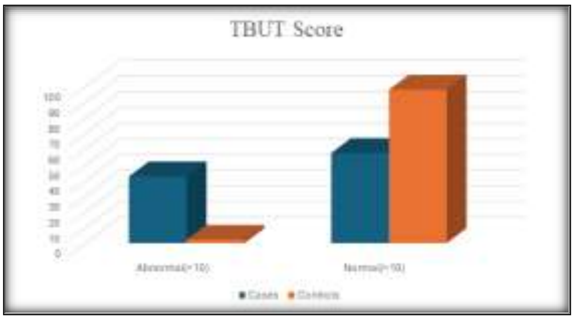
*Chisquare test. **Significant

Schirmer's 1 Test: A significant difference exists between cases and controls in tear production. Cases show a higher percentage of abnormal Schirmer-1 test values (27.65%) compared to controls (0%). This suggests that patients with pterygium often have reduced tear production.

Table 7: TBUT results & comparison between cases and controls

TBUT		Category		Total	Chi-square Value	P value
		Cases	Controls			
Abnormal (<10sec)	Count	20	1	21	22.14	<0.001**
	% within category	42.55%	2.12%			
Normal (>10sec)	Count	27	46	73		
	% within category	57.44%	97.87%			
Total	Count	47	47	94		
	% within category	100%	100%			

*Chi-square test. **Significant



Tear Film Stability: There is a notable difference in TBUT values, with 42.55% of cases having abnormal TBUT (<10 seconds) compared to only 2.12% of controls. This indicates that patients with pterygium are more likely to have unstable tear films.

Table 8: TMH results & comparison between cases and controls

TMH		Category		Total	Chi-square Value	P value
		Cases	Controls			
Abnormal (<0.3mm)	Count	43	4	47	64.72	<0.001**
	% within category	91.48%	8.51%			
Normal (>0.3mm)	Count	4	43	47		
	% within category	8.51%	91.48%			
Total	Count	47	47	94		
	% within category	100%	100%			

*Chi-square test. **Significant

Tear Meniscus Height: A significant number of cases (91.48%) have abnormal TMH values (<0.3mm), while only 8.51% of controls fall into this category. This suggests that reduced tear meniscus height is common in pterygium patients.

Table 9: Comparison of various tear film and meibomian gland parameters between cases and controls

	Cases		Controls		P	Confidence Interval	
	Mean	Std. Deviation	Mean	Std. Deviation		Lower	Upper
SCHRIMER-1 Test	10.77	3.25	15.09	3.13	0.001**	0.501	0.858
TBUT	10.04	3.72	14.15	3.56	0.001**	0.121	0.925
TMH	0.172	0.06	0.326	0.06	0.001**	-0.32	0.29
Lid Abnormalities Score	0.51	0.59	0.45	0.54	0.58	0.796	1.00
Meibomian Gland Expressibility Score	0.68	0.63	0.49	0.62	0.14	0.66	0.91
Meibum Score	1.13	0.82	0.62	0.57	0.001**	0.55	0.83

Tear Film and Meibomian Gland Health:

- Schirmer-1 Test: Cases have significantly lower mean values (10.77) compared to controls (15.09), indicating reduced tear production in cases.
- TBUT: Cases also show lower mean values (10.04) compared to controls (14.15), reflecting tear film instability.
- TMH: Cases have lower TMH (0.172) compared to controls (0.326), indicating reduced tear meniscus.
- Lid Abnormalities Score, Meibomian Gland Expressibility Score, and Meibum Score are all higher in cases than in controls, indicating worse meibomian gland function in patients with pterygium.

Table 10: Correlation of Ocular Surface Parameters with Lid Abnormalities, Meibomian Gland Expressibility, and Meibum Scores among Cases

	Lid Abnormalities Score		Meibomian Gland Expressibility Score		Meibum Score	
	R-correlation	P	R-correlation	P	R-Correlation	P
OSDI	0.464	0.001**	0.635	0.001**	0.784	0.001**
Schrimers-1	-0.324	0.026	-0.515	0.001**	-0.621	0.001**
TBUT	-0.090	0.547	-0.319	0.029	-0.442	0.002
TMH	-0.263	0.074	-0.457	0.001**	-0.572	0.001**

*Spearmans correlation. **Significant. R-correlation co-efficient. P-Significance level

Correlation in Cases:

- OSDI shows significant positive correlation with Lid Abnormalities Score (0.464), Meibomian Gland Expressibility Score (0.635), and Meibum Score (0.784), indicating that higher ocular surface disease index scores are associated with worse lid and meibomian gland health.
- Schirmer-1, TBUT, and TMH have significant negative correlations with meibomian gland scores, suggesting that better tear production and stability are associated with better meibomian gland health.

Table 11: Correlation of Ocular Surface Parameters with Lid Abnormalities, Meibomian Gland Expressibility, and Meibum Scores among Controls

	Lid Abnormalities Score		Meibomian Gland Expressibility Score		Meibum Score	
	R-correlation	P	R-correlation	P	R-correlation	P
OSDI	0.385	0.008	0.464	0.001**	0.459	0.001**
Schrimers-1	-0.265	0.072	-0.345	0.017	-0.441	0.002
TBUT	-0.001	0.992	-0.210	0.156	-0.280	0.056
TMH	-0.147	0.324	-0.102	0.494	-0.083	0.579

*Spearmans correlation. **Significant. R-correlation co-efficient. P-Significance level

Correlation in Controls:

- OSDI shows a positive correlation with Lid Abnormalities Score (0.385), Meibomian Gland Expressibility Score (0.464), and Meibum Score (0.459), similar to the cases.
- Schirmer-1 and TBUT have negative correlations with meibomian gland parameters, but these correlations are weaker than in cases, indicating less pronounced associations in the control group.

DISCUSSION

This case-control study aimed to elucidate the effects of pterygium on tear film stability & meibomian gland function by comparing these parameters between pterygium patients and healthy controls. The study reveals significant differences in ocular surface health between the two groups, providing insights into how pterygium affects the eye's tear film and meibomian glands.

Our study found a predominance of pterygium in individuals aged 31-50 years, comprising 57.5% of the cases. This aligns with existing literature, which indicates that pterygium is more prevalent in middle-aged individuals, likely due to prolonged exposure to environmental risk factors such as UV radiation, dust, and wind.[13] As people in this age group are often more engaged in outdoor activities, they are exposed to these risk factors more frequently. Conversely, the lower prevalence in the 61-70 age group, who accounted for only 8.5% of cases, may be attributed to decreased outdoor activity and reduced exposure to environmental elements as individuals age.[14]

The study observed a higher prevalence of pterygium in males (59.6%) compared to females (40.4%). This gender disparity is consistent with prior studies suggesting that men, who are more likely to work in outdoor environments and thus have increased UV exposure, are at higher risk for pterygium.[15,16] Additionally, hormonal differences might play a role, though further research is needed to explore the connection b/w sex hormones & pterygium development. Furthermore, Pterygium has been associated with more common disorders associated with high UV exposure, including hyperkeratosis, Xeroderma pigmentosum, Porphyria cutanea tarda, and basal cell cancer. Reactive oxygen species are produced by UV exposure, which may aid in the emergence of Pterygium.

A significant finding was the higher prevalence of pterygium in the right eye (74.5%) compared to the left eye (25.5%). This unilateral dominance may be influenced by handedness, which affects how much UV exposure each eye receives, as well as head positioning during outdoor activities.[17] The right eye's higher exposure to UV light might contribute to the greater incidence of pterygium on this side. However, further research is needed to better understand the factors behind this asymmetry.

Most patients presented with pterygium in the resting stage (57.4%), with fewer in the progressive stage (42.6%). This distribution suggests that many patients experience less active forms of the disease, which might be less symptomatic and less likely to prompt immediate treatment. Progressive pterygium, which is more severe and symptomatic, often necessitates surgical intervention.[18] This finding underscores the importance of early detection and monitoring to manage the progression of the disease effectively.

The study found that pterygium predominantly affects the nasal side (91.5%) compared to the temporal side (8.5%). This nasal predilection is supported by previous research, which attributes it to the anatomical and environmental factors, such as UV exposure from the temporal side of the eye.[19] The nasal side's greater exposure to sunlight, particularly in the context of light entering from the temporal side, likely contributes to this distribution.

Significant differences in Schirmer's 1 test results b/w pterygium patients and controls were observed, with a higher percentage of abnormal values (<10mm) in the pterygium group (27.65%) to that in controls (0%). This indicates that pterygium patients often have reduced tear production, which can exacerbate dry eye symptoms and promote the

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growth of pterygium.[20] Reduced tear production not only contributes to discomfort but may also perpetuate the inflammatory cycle associated with pterygium.

TBUT values were significantly lower in pterygium patients, with 42.55% showing abnormal TBUT (<10 seconds) compared to only 2.12% of controls. This finding highlights that pterygium is associated with more unstable tear films, leading to faster tear evaporation and exacerbation of dry eye symptoms.[21] The instability of the tear film in pterygium patients may further aggravate ocular surface inflammation and discomfort. Rajiv et al. ,reported that TBUT values were significantly reduced in cases of Pterygium indicating the inadequacy of tear film in these patients. Bekibele et al.also reported that TBUT was lower among cases than among their corresponding control eyes.[22,23]

The study observed abnormal tear meniscus height (TMH) values (<0.3mm) in 91.48% of pterygium cases,compared to 8.51% of controls. This significant reduction in TMH indicates lower tear volumes in pterygium patients, which may contribute to the dry eye symptoms and reflects the compromised ability to maintain an adequate tear reservoir.[24] Reduced TMH highlights the impact of pterygium on overall tear production and stability.

Comparative analysis of tear film and meibomian gland parameters revealed that pterygium patients have lower mean values for Schirmer-1 test, TBUT, and TMH, indicating reduced tear production and unstable tear films. Additionally, higher scores for lid abnormalities, meibomian gland expressibility, and meibum quality further suggest impaired meibomian gland function in these patients.[25] These findings underscore the multifaceted nature of pterygium's impact on both tear production and the quality of meibomian gland secretions.

Notably, our study is among the few to perform a dual assessment of both tear meniscus height (TMH) and meibum quality, offering a more comprehensive evaluation of aqueous and lipid components of the tear film. The correlation between OSDI score and meibum score (r = 0.784) is particularly strong compared to prior literature, reinforcing the central role of meibomian gland dysfunction in symptomatic dry eye among pterygium patients. This integrated evaluation has not been emphasized to this extent in previous studies and highlights the importance of addressing both aqueous deficiency and evaporative components of dry eye in clinical management.

Correlation analysis revealed statistically significant positive associations between Ocular Surface Disease Index (OSDI) scores and meibomian gland parameters—including lid margin abnormalities, expressibility scores, and meibum quality. This indicates that as ocular discomfort and subjective dry eye symptoms increase, there is a concurrent worsening of meibomian gland health. In other words, patients reporting higher symptom burden tend to have more severe gland dysfunction, further supporting the link between evaporative dry eye and pterygium-related ocular surface changes.

In contrast, Schirmer's I test values, Tear Film Break-Up Time (TBUT), and Tear Meniscus Height (TMH) demonstrated significant negative correlations with meibomian gland scores. This suggests that reduced aqueous tear production, faster tear evaporation, and lower tear volume are associated with more severe meibomian gland dysfunction. These findings reinforce the interdependence between tear film quantity, quality, and glandular integrity.

Interestingly, these correlations were also present in the contralateral (control) eyes, albeit with lower correlation coefficients and less statistical strength. This observation implies that while the relationship between tear film instability and MGD exists universally, it is more pronounced and clinically relevant in eyes affected by pterygium, possibly due to the additional mechanical and inflammatory stresses imposed on the ocular surface.

Collectively, these findings underscore the multifactorial nature of ocular surface disease in pterygium and highlight the importance of evaluating both subjective symptoms and objective tear and gland parameters when assessing disease severity and planning comprehensive management strategies.

Study Limitations and Future Research: While this study provides valuable insights, several limitations should be acknowledged. Firstly, the sample size was relatively small, which may limit the generalizability of the findings. With a limited number of participants, the results may not be representative of the broader population. Therefore, future studies with larger sample sizes are essential to validate these findings and ensure their applicability to a wider audience.

Secondly, the demographic diversity of the sample was limited. To comprehensively understand the variations in tear film stability and meibomian gland function across different populations, future research should include participants from diverse demographic backgrounds. This would help identify any potential differences or trends that may exist among various groups, enhancing the robustness of the conclusions drawn.

Moreover, this study primarily relied on clinical measurements and subjective assessments to evaluate tear film stability and meibomian gland function. While these methods provide valuable information, they may lack the precision and objectivity offered by advanced imaging techniques. Future research could benefit from incorporating methods such as meibography and optical coherence tomography. These techniques provide detailed and objective assessments of gland structure and function, allowing for a more comprehensive understanding of the underlying mechanisms and potential abnormalities.

Therefore, this study contributes valuable insights, its limitations include a small sample size, limited demographic diversity, and reliance on clinical and subjective assessments. Future studies with larger, more diverse populations and the incorporation of advanced imaging techniques are necessary to confirm these results and provide a more detailed and objective evaluation of tear film stability and meibomian gland function.

CONCLUSION

In conclusion, this study highlights the significant association between pterygium and ocular surface instability, particularly emphasizing the role of meibomian gland dysfunction (MGD) and evaporative dry eye. These findings have important clinical implications beyond symptom relief. Routine assessment of tear film parameters (Schirmer's I, TBUT, TMH) and meibomian gland function should be incorporated into the comprehensive evaluation of patients with pterygium.

Importantly, patients with progressive or symptomatic pterygium may benefit from the pre-operative treatment of MGD to optimize ocular surface health. Interventions such as warm compress therapy, lid hygiene, lipid-based lubricants, and dietary omega-3 supplementation could enhance tear film stability, reduce inflammation, and potentially improve post-operative outcomes, including faster healing and reduced recurrence risk.

Furthermore, altered tear film parameters may serve as markers of disease activity and could guide the timing of surgical intervention, especially in borderline or early-stage cases where structural encroachment is not yet severe. Patients with poor tear stability or high OSDI scores may warrant earlier or adjunctive treatment to prevent progression.

These insights call for a more integrated approach to managing pterygium, one that includes not just surgical excision but also a focus on modifiable ocular surface factors. Future longitudinal studies are needed to evaluate whether preoperative MGD management leads to better long-term surgical and visual outcomes.

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