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Impact of Pterygium on Dry Eye and Meibomian Gland Parameters: A Case- Control Study

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Abstract

Purpose

To investigate the impact of pterygium on dry eye parameters and meibomian gland morphology and function in a Nepalese population.

Methods

In this hospital-based case-control study 32 patients with pterygium (Group 1) and 32 age- and sex-matched healthy controls (Group 2) were studied at Bharatpur Eye Hospital, Nepal. Ocular Surface Disease Index (OSDI) scores, Schirmer II test, fluorescein tear film break-up time (TBUT), non-invasive tear break-up time (NIBUT), lipid layer thickness (LLT), and infrared meibography-based meiboscores were recorded and compared between groups.

Results

In this study, thirty-two eyes with pterygium (Group 1) and 32 control (Group 2) were analyzed. OSDI scores did not differ significantly between groups (16.4 ± 7.7 vs. 13.0 ± 7.5; p = 0.08). However, Schirmer II test values (7.03 ± 3.86 vs. 11.5 ± 6.83 mm; p = 0.002), NIBUT (6.38 ± 3.30 vs. 9.38 ± 4.43 s; p = 0.003), TBUT (5.09 ± 2.69 vs. 9.69 ± 4.16 s; p < 0.001), and LLT (45.0 ± 13.7 vs. 68.2 ± 18.0 nm; p < 0.001) were all significantly lower in Group 1. Meibomian gland loss was significantly greater in the upper (35.2 ± 10.2% vs. 29.1 ± 12.0%; p = 0.034) and lower tarsal plates (29.6 ± 10.3% vs. 24.2 ± 9.14%; p = 0.029) in the pterygium group.

Conclusion

Meibomian glands tend to show both morphological and functional alterations in eyes affected by pterygium. Also, pterygium is associated with significant impairment of aqueous tear production, tear film stability, lipid layer integrity, and meibomian gland structure. The correspondence between the location of pterygium and meibomian gland abnormality suggests a direct mechanical relationship. Therefore, in the clinical management of patients with pterygium, the presence of meibomian gland dysfunction and evaporative dry eye disease should be carefully evaluated and considered.

Introduction

Pterygium is a fibrovascular proliferative lesion originating from the bulbar conjunctiva that progressively extends across the limbus onto the corneal surface. The pathogenesis involves focal limbal stem cell failure, chronic UV-driven oxidative stress, inflammatory infiltration, connective tissue remodeling, and angiogenesis.[1,2] It can cause symptoms of discomfort, corneal irregularities, aesthetics issues thus

compromising visual acuity and quality of life.[2,3,4] The prevalence of this disease is highly variable, ranging from 1.1 to 40% in different groups investigated in various places of the world; taken as a whole data suggest an inverse correlation with the latitude.[5] The prevalence of pterygium is 2.4% where majority of population were of age-group 41-60.[6] According to WHO(World Health Organization), the Population Attributable factor of pterygium due to solar exposure was estimated as upper (0.74) 74% and lower (0.42) 42%.[7] Geographical latitude, residence in rural areas, age, race, sex, sun exposure, chronic irritation and inflammation are considered to be risk factors for pterygium [8,9].

Dry eye disease (DED) is a multifactorial condition of the tears and ocular surface that results in symptoms of discomfort, visual disturbance, and tear film instability, accompanied by increased tear osmolarity and ocular surface inflammation.[10] Epidemiological studies have reported global DED prevalence ranging from 14.6% to 57.5%.[11] Studies have shown the association between dry eyes and pterygium.[12–15] Meibomian gland function may be altered in pterygium patients, contributing to uncomfortable ocular symptoms and further destabilizing the tear film.[16] The exact relationship between abnormal tear film function and pterygium remains controversial.[17] Many authors have hypothesized that impaired tear function constitutes a risk factor for pterygium development, as hyperosmolarity and surface desiccation may promote limbal stem cell failure.[18,19,20] Conversely, other authors have proposed that pathological conjunctival, corneal, and eyelid changes arising from pterygium disrupt tear film function secondarily.[21]

Despite growing evidence supporting the association between pterygium and meibomian gland dysfunction (MGD), studies comprehensively assessing the lipid layer thickness (LLT) and non-invasive break-up time (NIBUT) alongside conventional tear film parameters and infrared meibography remain limited, particularly in South Asian populations.

The present study aimed to evaluate dry eye parameters and meibomian gland characteristics in pterygium patients compared to matched healthy controls at a tertiary eye care center in Nepal.

Methods

This was a case-control study conducted at Bharatpur Eye Hospital (BEH), Chitwan, Nepal. Ethical approval was obtained from the Institutional Review Board of the National Academy of Medical Sciences (NAMS), Bir Hospital, Kathmandu. The study adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment.

Patients aged 18 years and above diagnosed with pterygium in one or both eyes and without systemic illness were eligible for inclusion in the case group. Healthy volunteers matched by age and sex with no history of pterygium formed the control group. Exclusion criteria for both groups included: use of systemic medications affecting tear film (antihistamines, tricyclic antidepressants, oral contraceptives, diuretics), ocular surface disorders causing tear film abnormality, active ocular surface infections,

previous ocular surgery, current contact lens use, and inability or unwillingness to cooperate with examination procedures.

A detailed demographic history (age, sex, ethnicity, and address) was recorded. All tests were performed in standardized room-temperature conditions in the following sequence to minimize inter-test interference.

Ocular Surface Disease Index (OSDI)

Dry eye symptoms were assessed using the validated 12-item OSDI questionnaire.[12] Total scores were calculated as: OSDI = [(sum of scores for all questions answered) × 100] / [(total number of questions answered) × 4]. Scores were categorized as: 0–12 (no dry eye), 13–22 (mild), 23–32 (moderate), and > 32 (severe).

Fluorescein tear film break-up time (TBUT)

A fluorescein strip moistened with sterile saline was applied to the lower conjunctival fornix. After several complete blinks, the tear film was observed under cobalt blue slit-lamp illumination. The time from the last blink to the first dry spot was recorded; three measurements were taken and averaged. TBUT ≤ 10 seconds was considered abnormal. TBUT was graded as: Grade 1(> 10 seconds), Grade 2(≤ 10 seconds), Grade 3(≤ 5 seconds) and Grade 4(< 1 second; immediate dry spots).

Schirmer II test

Basic aqueous tear secretion was measured with topical anesthesia. After ensuring patient comfort, 0.5% proparacaine hydrochloride was instilled twice into the lower conjunctival sac at one-minute intervals. A Whatman No. 41 filter paper strip (5×35 mm, folded at 5 mm) was placed in the lower conjunctival fornix at the junction of the lateral one-third and medial two-thirds. Both eyes were tested simultaneously. After 5 minutes with eyes gently closed, the length of wetting was recorded. A value > 15 mm was considered normal, while < 10 mm indicated dry eye. Schirmer's grading was as follows: Grade 1: >10 mm, Grade 2: ≤10 mm, Grade 3: ≤5 mm and Grade 4: ≤2 mm.[14]

Meibography

Morphological assessment of the meibomian glands was performed using infrared meibography with the IBRA SBM Sistemi device. Upper and lower eyelid meibography images were captured and graded using the meiboscale [15]: Grade I = 0% loss; Grade II = < 25% loss; Grade III = 25–50% loss; Grade IV = 50–75% loss; Grade V = > 75% loss.[15] Percentage gland loss was recorded for upper and lower tarsal plates.

Lipid layer thickness (LLT)

LLT was measured using the interferometric imaging capability of the IBRA SBM Sistemi device, which quantifies the thickness of the lipid layer in nanometers. Reduced LLT is associated with increased evaporative dry eye risk.

The diagnosis made by OSDI dry eye questionnaires scores was correlated with clinical tests- TBUT < 10 seconds, Schirmer test values < 10 mm in 5 minutes and meibomian gland function test for both cases and controls and the outcome of these tests were analyzed and compared between these groups.

Statistical analysis

Collected data were checked, reviewed, and organized for completeness and accuracy, and it was entered into the Statistical Package for Social Science (SPSS version 26, IBM Corp., Armonk, N.Y., USA) for analysis. Kolmogorov-Smirnov test was used to determine whether the parameters are normally distributed. Continuous variables are expressed as mean ± standard deviation. Variables were compared using the independent samples t-test. A p-value < 0.05 was considered statistically significant.

Results

Demographic characteristics

A total of 64 participants were enrolled, with 32 in each group. The mean age was 44.7 ± 6.06 years across both groups, with the majority of participants in the 40–50 year age range in both cases (46.9%) and controls (59.4%). Age and sex were matched between groups, with 13 males (40.6%) and 19 females (59.4%) in each group. The majority of participants (85.9%) were from the Terai region, which is characterized by high ambient solar ultraviolet radiation exposure and correspondingly higher rates of pterygium.

Dry eye parameters

OSDI scores were higher in the case group (16.4 ± 7.7) than controls (13.0 ± 7.5), although this difference did not reach statistical significance (p = 0.08). In contrast, all objective tear film parameters were significantly impaired in the pterygium group. Schirmer II test values were lower in cases (7.03 ± 3.86 mm) compared to controls (11.5 ± 6.83 mm; p = 0.002). NIBUT was reduced in cases (6.38 ± 3.30 s) relative to controls (9.38 ± 4.43 s; p = 0.003). TBUT was also significantly lower in cases (5.09 ± 2.69 s vs. 9.69 ± 4.16 s; p < 0.001), as was LLT (45.0 ± 13.7 nm vs. 68.2 ± 18.0 nm; p < 0.001) (Table 1).

Meibomian gland parameters

Meibomian gland loss was significantly greater in both the upper and lower tarsal plates in the pterygium group. Upper tarsal gland loss was 35.2 ± 10.2% in cases versus 29.1 ± 12.0% in controls (p = 0.034), and lower tarsal gland loss was 29.6 ± 10.3% versus 24.2 ± 9.14% (p = 0.029) (Table 1).

Table 1
Comparison of Ocular Surface and Meibomian Gland Parameters Between Case and Control Groups

Parameter	Case (Mean ± SD)	Control (Mean ± SD)	p-value
OSDI score	16.40 ± 7.70	13.00 ± 7.49	0.080
Schirmer II test (mm)	7.03 ± 3.86	11.50 ± 6.83	0.002*
NIBUT (s)	6.38 ± 3.30	9.38 ± 4.43	0.003*
Lipid layer thickness (nm)	45.00 ± 13.70	68.20 ± 18.00	< 0.001*
TBUT (s)	5.09 ± 2.69	9.69 ± 4.16	< 0.001*
Meibomian gland loss, upper tarsal (%)	35.20 ± 10.20	29.10 ± 12.00	0.034*
Meibomian gland loss, lower tarsal (%)	29.60 ± 10.30	24.20 ± 9.14	0.029*

* Significant at p < 0.05. OSDI = Ocular Surface Disease Index; NIBUT = Non-invasive break-up time; TBUT = Tear break-up time; SD = Standard deviation.

Discussion

This hospital-based, non-interventional, case control study comprehensively evaluated the impact of pterygium on tear film and meibomian gland parameters in a Nepalese population. A total of 32 eyes with pterygium (Group 1) and 32 healthy eyes matched by age and sex (Group 2) were included. Most participants (85.9%) in both groups were from the Terai region, which is known for high sun exposure and a higher number of pterygium cases. The findings of this study reveal that pterygium exerts a significant adverse effect on the ocular surface, impairing aqueous tear production, tear film stability, lipid layer integrity, and meibomian gland morphology.

The OSDI scores, though numerically higher in the pterygium group (Case: 16.4 ± 7.7 ; Control: 13.0 ± 7.5), did not differ significantly between groups (p = 0.08). This contrasts with findings from Devebacak et al., who reported significantly higher OSDI scores in pterygium patients (Case :33.43 ± 20.86 ; Control: 22.55 ± 17.00; p < 0.001) in a Turkish cohort.[26] Several factors may account for this discrepancy. First, the present study's small sample size may have limited statistical power to detect moderate differences in a subjective, symptom-based measure with high inter-individual variability. Second, population-level differences in how ocular discomfort is reported and perceived may contribute, particularly in a rural Terai population where symptomatic presentation of chronic conditions is often underreported. Third, pterygium-specific symptoms such as redness and foreign body sensation may be normalized over time in patients living in high-UV environments, attenuating subjective dry eye scores even in the presence of objective disease.

All objective tear film parameters were significantly impaired in the pterygium group, which highlights a dissociation between subjective symptoms and objective ocular surface status. The Schirmer II test,

which measures basal tear secretion following topical anesthesia, was significantly lower in pterygium eyes (Case: 7.03 ± 3.86 mm; Control: 11.5 ± 6.83 mm; p = 0.002), consistent with reduced aqueous tear production. This finding aligns with Devebacak et al.[26] and Ye et al.,[16] both of whom reported significantly reduced Schirmer values in pterygium patients compared to controls. The disruption of the conjunctival epithelium and goblet cell loss due to presence of pterygium which is well documented in the context of pterygium-related squamous metaplasia[19] may have contributed to aqueous deficiency through impaired mucin secretion and altered tear meniscus distribution. Ozsutcu et al. demonstrated elevated tear osmolarity in pterygium patients, reflecting the net effect of increased evaporation and reduced secretion on tear film composition.[18]

The TBUT and NIBUT were markedly reduced in the pterygium group. A study by Munir et al. found that over half of people with pterygium had dry eye, compared to only about one-fourth of healthy individuals.[27] The value of TBUT in patient with pterygium is 5.09 ± 2.69 seconds while it was 9.69 ± 4.16 seconds in controls, p < 0.001. The NIBUT value in cases was 6.38 ± 3.30 seconds while it was 9.38 ± 4.43 seconds in controls, p = 0.003. These findings indicate significant impairment of tear film stability and are consistent with prior reports.[16,26] Notably, the use of NIBUT in the present study offers a methodological advantage over fluorescein-based TBUT, as it avoids fluorescein-induced dilution of the tear film and thus provides a more physiologically accurate assessment of tear stability.[23] The greater significance level observed for TBUT and NIBUT compared to the Schirmer II test reinforces the concept that evaporative dry eye, mediated by lipid layer disruption and meibomian gland pathology, is the dominant subtype of tear film dysfunction in pterygium patients. This pattern has been observed across multiple studies and may be explained by the physical disruption of the smooth tear film spreading surface by the fibrovascular pterygium mass, as well as by inflammatory mediators that impair meibomian gland secretion.

The most novel finding of the present study is the significant reduction in lipid layer thickness (LLT) in the pterygium group (45.0 ± 13.7 nm vs. 68.2 ± 18.0 nm; p < 0.001). LLT is a direct quantitative marker of meibomian gland lipid output and its reduction is a hallmark of evaporative dry eye disease.[10] The substantial reduction in LLT observed in this study is consistent with the meibomian gland loss findings and provides a mechanistic link between structural gland damage and functional tear film impairment. Unlike TBUT, which is influenced by multiple factors, LLT provides a parameter-specific assessment of the lipid layer that is not confounded by fluorescein instillation or observer timing. The magnitude of the LLT reduction (34% relative reduction compared to controls) underscores the severity of lipid layer compromise in pterygium and supports the classification of pterygium-associated dry eye as predominantly evaporative in etiology.

Meibomian gland loss was significantly greater in both upper (35.2 ± 10.2% vs. 29.1 ± 12.0%; p = 0.034) and lower tarsal plates (29.6 ± 10.3% vs. 24.2 ± 9.14%; p = 0.029) of the pterygium group. These findings are consistent with those of Devebacak et al., who found significantly elevated upper, lower, and total meiboscores in pterygium patients (p < 0.001 for all), and with Wanzeler et al., who identified meibomian gland alterations in 88% of pterygium patients.[26,15] Wu et al. similarly demonstrated a significant

correlation between meibomian gland dropout and tear film instability in pterygium.[17] Ye et al. also reported worse tear film stability and greater meibomian gland loss in pterygium patients compared to controls in a Chinese population, corroborating the consistency of these findings across diverse cohorts.[16]

The mechanisms underlying meibomian gland dysfunction in pterygium are likely both mechanical and inflammatory in nature. Mechanically, the fibrovascular mass of the pterygium may exert direct pressure on the tarsal plate and meibomian gland during blinking, leading to gland compression, and gland atrophy. This is supported by the observation in Devebacak et al. and Wanzeler et al. that meibomian gland loss is disproportionately located on the nasal side of the eyelid, corresponding to the typical location of nasal pterygium.[26,15] The spatial correspondence between gland dropout and pterygium topography strongly implicates a direct mechanical mechanism. However, our study did not assess this spatial distribution due to methodology limitations, which represents an important area for future investigation.

The geographic and demographic context of this study merits discussion. The predominance of participants from the Terai region (85.9%), characterized by high ambient UV radiation and warm-dry climate, reflects the environmental risk profile of this population. Future studies in this population should consider stratifying findings by pterygium grade, UV exposure history, and agricultural occupation, all of which are prevalent confounders in the Terai context.

The clinical implications of these findings are significant. Pterygium represents one of the most common ophthalmic conditions encountered in South Asia. The high prevalence of concurrent meibomian gland dysfunction and evaporative tear film instability in this population means that managing pterygium in isolation without addressing the ocular surface is likely to yield suboptimal outcomes.

This study has several limitations. The relatively small sample size (n = 32 per group) limits statistical power for subjective endpoints such as OSDI and may reduce the general stability of the findings. The predominance of Terai-region participants restricts applicability to other geographic and ethnic groups within Nepal. Pterygium was not graded by extension or invasiveness, precluding dose-response analysis between pterygium severity and the degree of tear film or meibomian gland impairment. The spatial asymmetry of meibomian gland loss relative to the pterygium location was not assessed in this study, representing an important mechanistic gap. Anterior segment OCT-based pterygium characterization was not performed due to resource constraints. Future prospective studies with larger samples, pterygium grading, and meibomian gland asymmetry analysis would substantially strengthen our understanding of these relationships in this population.

Conclusion

Pterygium is associated with significant impairment of aqueous tear production, tear film stability, and meibomian gland morphology. The additional quantification of lipid layer thickness and non-invasive tear break-up time in this study adds to the multidimensional characterization of ocular surface dysfunction in pterygium patients. Comprehensive tear film assessment including tear film stability test, LLT and meibography should be considered standard of care in the evaluation and management of pterygium.

List of Abbreviations

BEH Bharatpur Eye Hospital

DEWS Dry Eye WorkShop

DED Dry Eye Disease

LLT Lipid Layer Thickness

MG Meibomian Gland

MGD Meibomian Gland Dysfunction

NAMS National Academy of Medical Sciences

NIBUT Non-invasive Tear Break-up Time

OD Oculus Dexter (Right Eye)

OS Oculus Sinister (Left Eye)

OSDI Ocular Surface Disease Index

SD Standard Deviation

SPSS Statistical Package for Social Sciences

TBUT Tear Film Break-up Time

UV Ultraviolet

WHO World Health Organization

Declarations

Consent for publication: Not Applicable.

Availability of data and materials: The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare no conflicts of interest.

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Ethics approval and consent to participate: Ethical approval was obtained from the Institutional Review Board of the National Academy of Medical Sciences, Bir Hospital, Kathmandu, Nepal. The study adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to inclusion in the study.

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Conflicts of Interest

The authors declare no conflicts of interest.

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