



ORIGINAL ARTICLE

Effects of inner lash line eyeliner on tear film integrity among young adult women

Ayodeji IGE, Oluwasola OJO, Dolapo OPAWALE

ABSTRACT

Background. Eyeliner applied to the inner lash line (waterline) brings cosmetic material into direct contact with the meibomian gland orifices and the precorneal tear film, raising concerns about potential tear film disruption. This study aimed to evaluate the impact of daily inner lash line eyeliner application on tear film integrity in female university students. **Methods** Nineteen female students (mean age: 19.2 ± 1.9 years; range: 17–24 years) applied a retractable pencil eyeliner (Colossal Kajal, Maybelline, New York, USA) to the inner lash line of both eyes daily for one month. Each participant served as her own control. Tear quantity (Schirmer's test) and tear quality (tear break-up time, TBUT) were assessed before and after the intervention. **Results.** TBUT decreased significantly after one month of inner lash line eyeliner use (23.39 ± 9.95 s vs 9.57 ± 2.58 s; Wilcoxon $W = 0$, $p < 0.001$; Cohen's $d = 1.29$; 95% CI: 8.68–18.98 s). Post-intervention, 12 of 19 participants (63.2%) exhibited abnormal TBUT values (<10 s), whereas none did at baseline. Tear production, as measured by Schirmer's test, did not change significantly (27.53 ± 8.38 mm vs 23.95 ± 11.25 mm; $t(18) = 1.385$, $p = 0.183$; $d = 0.32$). **Conclusion.** Daily application of eyeliner to the inner lash line significantly reduces tear film stability without significantly affecting tear production. These preliminary findings suggest that disruption of meibomian gland orifices and contamination of the lipid layer may underlie this effect. Larger randomized controlled trials with examiner masking and washout periods are warranted.

Keywords: Eyeliner, Inner lash line, Waterline, Tear film integrity, Tear break-up time, Schirmer's test, Meibomian gland dysfunction, Dry eye, Ocular cosmetics.

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1. INTRODUCTION

Ocular cosmetics, particularly eyeliner, are among the most widely used beauty products globally, with surveys indicating use by over 60% of women in various populations [1]. Applied in proximity to the ocular surface, eyeliner formulations contain waxes, pigments, preservatives, and emollients that may migrate into the pre-corneal tear film and disturb its structural integrity [2].

The tear film is a trilaminar structure comprising an outer lipid layer produced by the meibomian glands, a middle aqueous layer secreted by the lacrimal glands, and an inner mucin layer derived from conjunctival goblet cells [3]. Disruption of any layer particularly the lipid layer results in accelerated tear evaporation, reduced tear break-up time (TBUT), and the symptom complex of dry eye disease (DED), characterised by ocular discomfort, visual disturbance, and ocular surface damage [4].

The site of eyeliner application is a critical determinant of its effect on the tear film. Wang and Craig [2] demonstrated that eyeliner applied to the inner lash line (waterline) migrates into the tear film at a significantly faster rate and in greater quantities than eyeliner applied to the outer lash margin, with particulate contamination detectable within five minutes of inner lash line application. This is

mechanistically explained by the proximity of the inner lash line to the meibomian gland orifices: cosmetic material deposited here can directly obstruct these orifices, impair meibum secretion, and destabilise the lipid layer [5,6]. Despite this evidence, waterline eyeliner application remains a common practice, particularly among young women.

Prior studies have consistently reported eyeliner-related TBUT reduction and meibomian gland dysfunction [5–7]. However, studies isolating the inner lash line application route in a young university-age population over a defined one-month period are limited. This study therefore aimed to evaluate the impact of daily inner lash line eyeliner application on tear quantity (Schirmer's test) and tear quality (TBUT) among female students at the University of Ilorin, using a within-subject design in which each participant served as their own control.

2. MATERIALS AND METHODS

Study Design and Setting

A quasi-experimental, within-subject pretest-posttest study was conducted at the University of Ilorin Optometry Clinic, Ilorin, Kwara State, Nigeria, from December 2024 to January 2025. Each participant served as their own control, with baseline measurements obtained prior to eyeliner exposure and post-intervention measurements obtained after one month of daily inner lash line application. This design controls for inter-individual variability in baseline tear function.

Participants

Nineteen female students (mean age: 19.2 ± 1.9 years; range: 17–24 years) were recruited using purposive convenience sampling. Inclusion criteria: female sex, University of Ilorin student status, written informed consent (and parental/guardian consent for participants under 18 years), and no prior ocular conditions. Exclusion criteria: frequent contact lens wear, anterior segment disorders, history of ocular surgery, known cosmetic allergies, and current use of medications affecting tear production.

Sample Size

Sample size was calculated using the formula $n = Z^2 p(1-p)/d^2$, where $Z = 1.96$ (95% confidence level), $p = 0.27$ (estimated prevalence of dry eye symptoms in young women; [8]), and $d = 0.20$ (margin of error), yielding a minimum of 19 participants. Post hoc power analysis confirmed >99% power to detect the observed TBUT effect ($d = 1.29$) and 34% power for the Schirmer's effect ($d = 0.32$), indicating adequate power for the primary outcome.

Participant Selection and Product Rationale

Prior to commencement of the study, a preliminary survey was conducted among the target student population to identify the eyeliner products most commonly used for waterline application. The Colossal Kajal retractable pencil eyeliner (Maybelline, New York, USA) was identified as the product with the highest prevalence of use within this population and was therefore selected to reflect ecologically valid exposure conditions.

Intervention and Examiner Protocol

Each participant received a standardised Colossal Kajal retractable pencil eyeliner (Maybelline, New York, USA) with written and verbal instructions to apply it to the inner lash line (waterline) of both eyes daily for one month. The study was conducted under direct clinical supervision at the University of Ilorin Optometry Clinic. Baseline tear film parameters were assessed in all participants before eyeliner application commenced, and confirmed to be within normal limits at enrolment. All participants were non-habitual eyeliner wearers at baseline, providing a clean pre-exposure reference point. Follow-up measurements were obtained by the same examiner after one month of daily exposure, ensuring consistency of technique and equipment. Compliance was additionally assessed by participant self-report at follow-up.

Outcome Measures

Schirmer's Test: Tear quantity was assessed without anaesthesia using a standardised Schirmer strip (Eagle Vision, Memphis, USA) placed in the lower conjunctival fornix for five minutes. Wetting <10 mm was considered abnormal.

Tear Break-Up Time (TBUT): A fluorescein strip (BioGlo, HUB Pharmaceuticals) was applied to the inferior conjunctival fornix. Using a slit lamp biomicroscope with cobalt blue filter, three measurements per eye were recorded and averaged. TBUT <10 seconds was considered abnormal; <5 seconds indicative of dry eye.

Data Analysis

Normality of difference scores was assessed using the Shapiro-Wilk test. TBUT differences were non-normally distributed ($W = 0.898$, $p = 0.044$); the Wilcoxon signed-rank test was therefore used as the primary analysis. Schirmer's differences were normally distributed ($W = 0.947$, $p = 0.357$) and were analysed using the paired t-test. Binocular values represent the mean of OD and OS. Cohen's d and 95% CIs are reported. Analyses were performed in Python (SciPy v1.11). Statistical significance: $p \leq 0.05$.

Ethical Considerations

The study adhered to the Declaration of Helsinki. Ethical approval was obtained from the University of Ilorin Ethics Committee. Written informed consent was obtained from all participants; those under 18 years also provided parental/guardian consent. All data were anonymised before analysis.

3. RESULTS

Participant Characteristics

All 19 enrolled participants completed the study (mean age: 19.2 ± 1.9 years; range: 17–24 years). All were female students from diverse university faculties who applied Colossal Kajal eyeliner daily to the inner lash line of both eyes for one month.

Tear Quantity: Schirmer's Test

Schirmer's test revealed no statistically significant change in tear production following the intervention. Mean binocular values were 27.53 ± 8.38 mm at baseline and 23.95 ± 11.25 mm post-intervention (mean difference: 3.58 ± 11.27 mm; $t(18) = 1.385$, $p = 0.183$; $d = 0.32$; 95% CI: -1.85 to 9.01 mm), confirmed by the Wilcoxon test ($p = 0.124$). The proportion with abnormal values (<10 mm) changed from 1/19 (5.3%) to 3/19 (15.8%), a non-significant difference. Individual data revealed bidirectional change, with 8 of 19 participants showing increased values post-intervention, indicating no consistent directional effect on tear quantity (Figure 1).

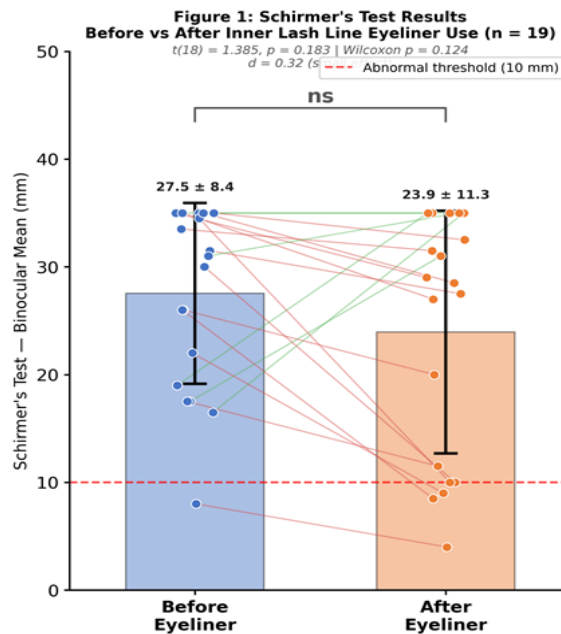


Figure 1. Schirmer's test binocular mean values before and after one month of inner lash line eyeliner use ($n = 19$). Bars represent mean $\pm$ SD; individual data points are shown with connecting lines (green = increase; red = decrease). Dashed line = abnormal threshold (10 mm). ns = not significant ($p = 0.183$).

Tear Quality: Tear Break-Up Time

TBUT declined significantly following the intervention. Mean binocular TBUT was 23.39 ± 9.95 seconds at baseline and 9.57 ± 2.58 seconds post-intervention (mean reduction: 13.83 ± 10.68 seconds; Wilcoxon $W = 0$, $p < 0.001$; $d = 1.29$; 95% CI: 8.68–18.98 seconds). Results were consistent across both eyes (OD: $W = 2$, $p < 0.001$; OS: $W = 0$, $p < 0.001$). Post-intervention, 12/19 participants (63.2%) had TBUT < 10 seconds, compared with none at baseline. No participant crossed the 5-second dry eye threshold. All 19 participants demonstrated reduced TBUT after eyeliner use (Figure 2).

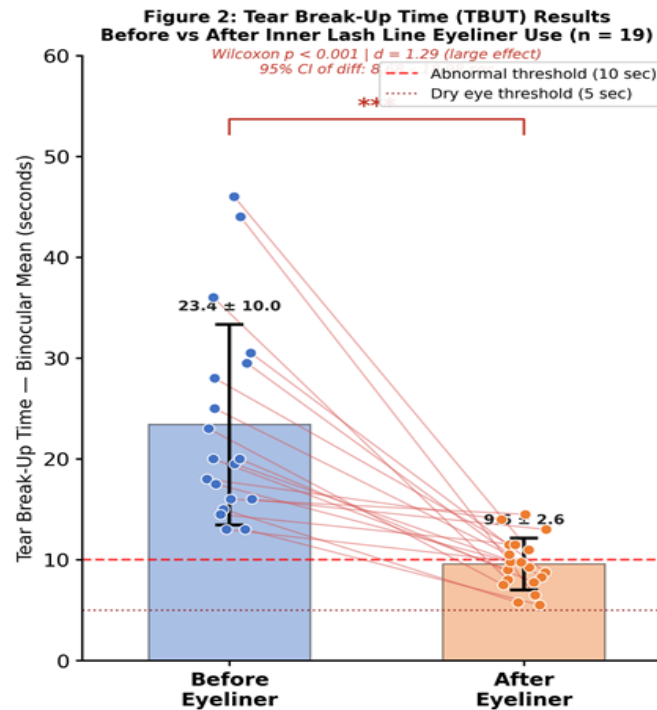


Figure 2. TBUT binocular mean values before and after one month of inner lash line eyeliner use ($n = 19$). Bars represent mean $\pm$ SD; individual data points shown with connecting lines. Red dashed = abnormal threshold (10 sec); dark-red dotted = dry eye threshold (5 sec). *** Wilcoxon $p < 0.001$; Cohen's $d = 1.29$.

4. DISCUSSION

The main finding of this study was a significant reduction in TBUT after one month of daily inner lash line eyeliner use ($d = 1.29$; $p < 0.001$), with no significant change in Schirmer's test values ($p = 0.183$). This is in agreement with earlier reports [5–7]. Eyeliner users have also been found to have higher OSDI scores above 13 compared to non-users (42.93% vs. 33.38%; $p < 0.001$), with lid-margin application specifically associated with an even higher rate (48.17%; $p < 0.001$) [13]. A DED prevalence of 71.6% has been reported among women who used eye cosmetics regularly, with daily inner eyeliner use specifically linked to a higher prevalence of dry eye symptoms [11].

The inner lash line is the highest-risk site for eyeliner application. It has been shown that eyeliner applied to the waterline migrates into the tear film faster and in greater amounts than eyeliner applied to the outer lash margin, and this can be detected within five minutes of application [2]. The waterline lies directly over the meibomian gland orifices, so cosmetic material deposited there can block these orifices, reduce meibum secretion, and weaken the lipid layer that slows tear evaporation [5,9]. The wax-based formulation of Colossal Kajal is particularly likely to cause orifice blockage [6]. It has also been reported that pigmented cosmetic material can accumulate in the lacrimal system and meibomian gland orifices across different product types, not just pencil eyeliner [12]. The TBUT reduction seen in this study fits within that pattern. Meibography was not done in this study, so gland-level changes

could not be confirmed directly. Grade 2–3 meibomian gland dysfunction on meiboscoring has been reported in 85.7% of eyeliner users compared to 47.6% of controls [6], which gives some indication of what might have been found had meibography been performed here. All 19 participants showed a drop in TBUT, and 63.2% fell below the 10-second threshold after one month of eyeliner use.

Schirmer's test values did not change significantly ($p = 0.183$), which points to an evaporative rather than aqueous-deficient mechanism. This pattern, where TBUT falls but Schirmer's values are preserved, is typical of meibomian gland-related dry eye. It has been reported that neither lipid-based eye drops nor liposomal spray produced a significant change in NITBUT or tear evaporation rate in eyeliner wearers [9], which suggests that lipid layer disruption in this group is not easily reversed even with treatment. DED has also been found to be more severe in cosmetic users who did not wash off their cosmetics [11], which suggests that residual cosmetic material left on the lids may compound the problem beyond the act of application alone. It has been reported that 23.37% of patients were unwilling to stop using cosmetics even when advised to by their eye care provider, and only 48.19% of eye care providers routinely asked about cosmetic use during consultations [13]. This suggests that asking about cosmetic use should be a routine part of ocular surface assessment, and that patient counselling on this topic may need more emphasis in clinical practice.

Limitations

The sample size ($n = 19$) was sufficient for the large TBUT effect but inadequate to detect small Schirmer's effects; future work in larger samples is needed to confirm tear quantity findings. Examiner masking was not employed, introducing potential expectation bias for TBUT, which has a subjective endpoint. Participant compliance with inner lash line application was assessed by self-report without objective verification. Only one eyeliner formulation was tested; findings may not generalise to liquid, gel, or differently-formulated liners. Meibography was not performed, limiting mechanistic inference about meibomian gland morphology. Finally, the absence of a washout measurement prevents conclusions about the reversibility of the observed effects.

5. CONCLUSION

Daily inner lash line eyeliner application significantly reduces tear film stability in young adult women, with a mean TBUT reduction of 13.83 seconds, a large effect size ($d = 1.29$; $p < 0.001$), and 63.2% of participants crossing the abnormal threshold after one month. Tear production was not significantly altered ($p = 0.183$). Findings implicate meibomian gland orifice disruption and lipid layer contamination as the primary mechanisms. Patients should be counselled against waterline eyeliner application. A larger, prospective randomised controlled trial with examiner masking, objective compliance monitoring, meibography, and washout measurements is warranted.

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