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The effects of eyelash extensions on the ocular surface

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ABSTRACT

Purpose: To investigate the effects of eyelash extensions on the ocular surface.
Methods: This prospective study included 32 participants with eyelash extensions in both eyes. Symptoms and clinical parameters such as conjunctival vascular density, tear meniscus height (TMH), noninvasive tear break-up time, bulbar redness, meibography, lipid layer thickness, and corneal staining were assessed in the right eyes. These measurements were taken at baseline and 1 h, 1 day, 1 week, and 1 month after eyelash extensions were applied.
Results: At 1 h after eyelash extensions, ocular symptoms were reported by 27 participants (84.44 %), the most common being foreign body sensation (59.38 %). However, the Ocular Surface Disease Index scores were not statistically different between baseline, 1 week, and 1 month after eyelash extension ($P > 0.05$). TMH increased significantly at 1 h after eyelash extensions, from 0.27 ± 0.08 mm (baseline) to 0.29 ± 0.07 mm ($P = 0.02$). Subsequently, TMH decreased and was the lowest at 1 week at 0.24 ± 0.08 mm. First tear break-up time and average tear break-up time decreased to the lowest at 1 week after eyelash extension, with 8.36 ± 4.6 s and 10.71 ± 4.99 s, respectively, both of which were statistically different from baseline ($P < 0.05$). Corneal staining score was highest at 1 h after eyelash extensions at 0.78 ± 1.34. However, there were no significant differences in the conjunctival vascular density, bulbar redness, meiboscore, or lipid layer thickness.
Conclusion: This study demonstrates that eyelash extensions can lead to an imbalance in ocular surface homeostasis, resulting in corneal epithelial defects and short-term decreased tear film stability.

1. Introduction

Physical beauty is often regarded as an advantageous and sought-after trait [1]. Humans, in particular pay attention to the eyes and periocular areas when they first encounter someone. Eyelashes significantly enhance aesthetic [2]. Various techniques, including extensions, have been employed to enhance the eyelashes' overall prominence. Eyelash extension involves the attachment of synthetic lashes made of chemical fibers or other materials to natural lashes using glue [3]. Eyelash extensions have become increasingly popular worldwide, especially among young women [3,4]. A survey in a Nigerian tertiary institution found that 38.7 % of respondents used eyelash extensions [1].

Among beauty treatments, eyelash extensions currently lead to the highest number of eye clinic consultations [5]. Eyelash extensions may cause discomfort such as itching, eye redness, pain, and eyelid heaviness [1]. In Ghana, most (96.7 %) studied participants experienced one or more eye symptoms [6]. Although eyelash extensions may cause some discomfort, people repeatedly extend their eyelashes in pursuit of beauty [1]. Koffuor et al., [6] showed that approximately 50 % of Ghanaian women who had prior experience with eyelash extension had extended their eyelashes more than three times. Additionally, 67.2 % of the clients said they would fix their eyelashes again. Nowadays, eyelash extensions are very popular and associated with numerous symptoms of ocular discomfort. However, there have been few studies on eyelash extensions, most involving questionnaires [1,3,5,6]. Therefore, it is necessary to conduct prospective experimental studies to investigate the effects of eyelash extension on the ocular surface.

This study aimed to investigate the effects of eyelash extensions on the ocular surface and whether they worsen tear film stability, providing

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additional evidence on whether certain ocular surface medical monitoring or intervention is required after eyelash extension.

2. Materials and methods

2.1. Study population

Thirty-two adult females interested in eyelash extensions were prospectively recruited after obtaining approval from the Research Ethics Committee of Wenzhou Medical University (code:2023–023-K-18–02). This prospective, self-controlled study adhered to the principles of the Declaration of Helsinki. Written informed consent was obtained from all study participants before enrollment.

Individuals aged > 18 years, able to consent, and without ocular symptoms were included in the study. Participants were excluded if they had abnormal eyelid position or function (e.g., impingement, ectropion), worn contact lenses within the last 30 days, had eyelash extensions in the past 6 months, had a history of corneal disease, had glaucoma, or other ocular diseases, underwent refractive surgery, double eyelid blepharoplasty, had a systemic disease affecting eye health (e.g., rheumatoid arthritis, diabetes, thyroid disease, autoimmune disease, or dry syndrome), used topical medications (e.g., glaucoma drops), or systemic treatments.

2.2. Experimental design

Thirty-two participants underwent clinical assessment at baseline and within 1 h, 1 day, 1 week, and 1 month after eyelash extensions. Eyelash extensions were performed on both eyes, and the right eye was assessed. Eyelash extensions were applied to the upper lid only. To exclude potential effects of changes in eye make-up on the ocular surface, participants were required to wear the same make-up as they did before their eyelash extensions. Moreover, participants were not allowed to use eye drops such as artificial tears throughout the study. The sequence of tests progressed from the least invasive to the most invasive. The following tests were performed sequentially: Ocular Surface Disease Index (OSDI) questionnaire, anterior segment-optical coherence tomography angiography (OCTA, VG100D, SVision Imaging, Luoyang, China; to assess conjunctival vascular density), Keratograph 5 M (Oculus, Wetzlar, Germany) to assess tear meniscus height, noninvasive tear break-up time, bulbar redness, and meibography), LipiView interferometer (Tear Science INC, Morrisville, North Carolina, USA, Johnson, and Johnson; to assess lipid layer thickness), slit-lamp (SLE-8E, KangHuaRuiMing, Chongqing, China; to access images of anterior segment and corneal staining scores). All clinical tests were conducted in an air-conditioned room with a temperature of approximately 20 °C to 26 °C and humidity of approximately 45 % to 65 % to maintain the same environmental conditions. The eyelash extensions and assessments were performed as described in the succeeding section.

2.3. Eyelash extensions

Two experienced beauty professionals performed all eyelash extensions. The procedure was as follows (Fig. 1, Appendix Video 1): 1) After cleaning and sterilizing the hands, the beauty professional cleaned the eyelashes with eyelash-cleansing mousse (Oculimax, Guangdong Crafty Beauty Biotechnology Co., Ltd.) and dried them. 2) An eye patch was used to isolate the participant's upper and lower lashes. 3) The upper eyelid was pulled up and fixed with tape to make the eyelashes fully visible. 4) The end of the false lashes was held with tweezers, and

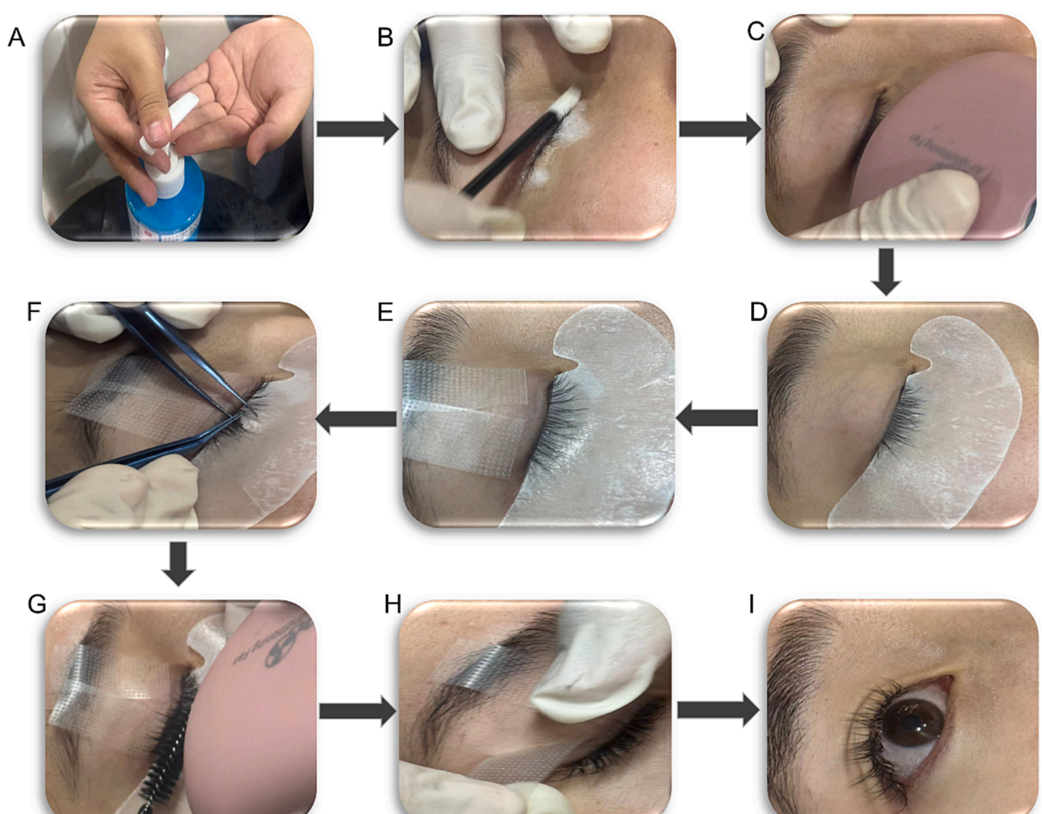

Fig. 1. Eyelash extension process. After cleaning and sterilizing hands (A), the beauty professional cleans the eyelash with eyelash cleansing mousse (B) and blow-dries it (C). The participant's upper and lower eyelashes were isolated with eye patches (D), and the upper lid is secured with anti-allergenic tape (E). Eyelash extensions are applied next (F). After the extensions are applied, the eyelashes are dried with a small fan, combed, and inspected (G). After checking, the eye patch and anti-sensitizing tape are removed (F) and the eyelash extension process is complete (I).

approximately two-thirds of the root was dipped into lash glue (Oculimax, Guangdong Crafty Beauty Biotechnology Co.), approximately 1 mm from the lid margin (Fig. 2). 5) After applying the extensions, a manually operated fan was used to cool the glue until it solidified. This process took approximately 5–10 min. 6) The eyelashes were brushed with a lash brush to check if they were firmly attached, and if any had fallen off, they needed to be replenished. 7) After completing the application, the tape and eye patches used for fixation were removed.

2.4. Ocular surface symptom assessment

As the OSDI is a questionnaire that assesses participants' complaints within the past 1 week, the OSDI questionnaire was completed independently by all participants before, 1 week after, and 1 month after eyelash extensions. It measures the severity of symptoms, functional problems, and environmental triggers and consists of 12 questions. The questions were asked regarding a 1-week recall period. The OSDI score= (25 × total score)/number of questions answered. The subscale scores were computed similarly. The higher the score, the more severe the ocular surface symptoms [7]. Furthermore, 1 h after the eyelash extensions were applied, the participants were asked if they had any discomfort such as itching, pain, foreign body sensation, casting of shadows in vision, or eyelid heaviness.

2.5. Clinical assessment

2.5.1. Anterior segment-optical coherence tomography angiography assessment

OCTA examination was performed using a swept-source OCTA (VG100D, SVision Imaging, Luoyang, China), which operates near 1050 nm, with a scan of 100,000 AScans/s and a wide field of 56°. Captures were performed using the AS Angio scan mode with a scan depth of 4.1 mm. Each 6 × 6 mm^2 volume scan comprised 384 A-scans per B-scan, for 384B-scan locations. The participants looked at a fixation point located on the temporal or nasal side of the eye, and the scanning area was a 6 × 6 mm area tangent to the nasal or temporal side of the corneal limbus. En-face images were generated using built-in software (Ver. 1.44.2; SVision Imaging). Superficial-layer flow images were created with en-face maximum projection from the conjunctival epithelium to a depth of 200 μm [8]. Vessel density was automatically measured using the software. Vessel density was measured three times, and the average value was used.

2.5.2. Keratograph 5 M

Using Keratograph 5 M according to the manufacturer's instructions, different modes were selected and tested sequentially. The order of inspection was as follows:1) Tear meniscus height (TMH): TMH was measured vertically from the middle of the cornea, just below the lid margin, to the upper visible tear using the measurement tool provided in the measurement software of the machine. TMH was measured three times and then averaged. 2) The noninvasive tear break-up time (NIT-BUT) was recorded as the first tear break-up time (FTBUT), and the average tear break-up time (ATBUT) based on the principle that the circle projected by Placido's ring on the cornea appears to be fissured when the tear film breaks up. FTBUT and ATBUT were measured three times and then averaged.; 3) Bulbar redness: automated bulbar redness measurements were measured in the "R-Scan" mode; 4) Meibography: The Meibo-scan mode of the Keratograph 5 M system observed the upper and lower eyelids. The proportion of area loss in the total meibomian gland area was calculated using ImageJ software and used to grade the degree of meibomian gland dropout, which can be graded from 0 to 3 according to severity [9]. The scores for the upper and lower lids were summed to provide a scale range of 0–6 points. This result is termed the meiboscore.

2.5.3. LipiView interferometer

The lipid layer thickness (LLT) was recorded objectively with the LipiView Interferometer. LLT is expressed in interference color units (ICU), where one ICU corresponds to approximately 1 nm, with an upper limit of 100 nm.

2.5.4. Slit-lamp assessment

The anterior segment was photographed and corneal staining scored sequentially with a slit lamp. The cornea was assessed using fluorescein dye and categorized into five regions (central, superior, nasal, inferior, and temporal). Each quadrant was graded on a 5-point scale of 0–4 severity, with a total score of 0–20. Severity was assessed using a 5-point scale:0 (no staining), 1 (micropunctate), 2 (macropunctate), 3 (coalesced macropunctate), and 4 (patch ≥ 1 mm), as previously described [10].

2.6. Statistical analysis

Statistical analyses were performed using IBM SPSS software (version 26.0; IBM Corp., Armonk, NY, USA). Normal distributions were

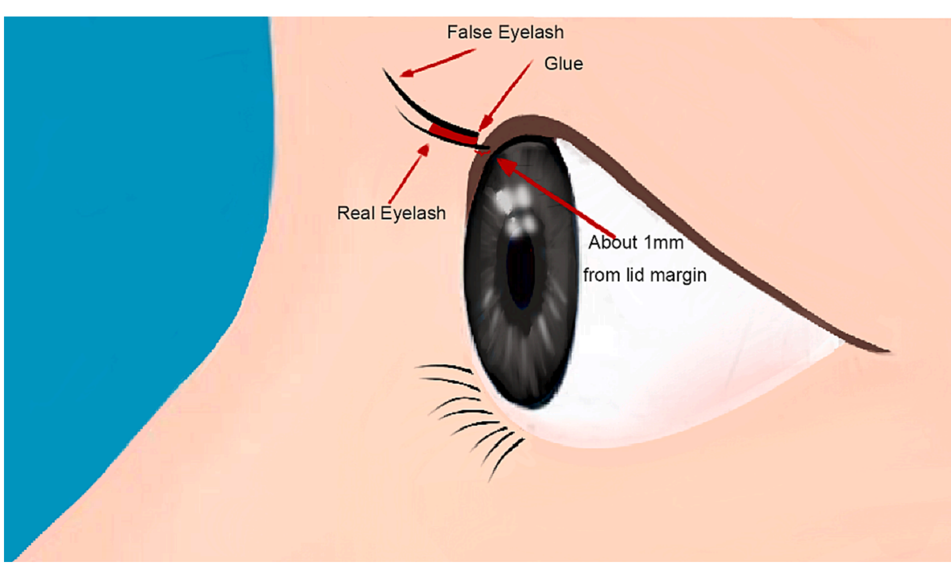

Fig. 2. Eyelash extension schematic. False eyelashes are glued to the real eyelashes, about 1 mm from the lid margin. False eyelashes should be adhered to at least 1/3 of the length of the real eyelashes, and the curvature of the extensions should be consistent.

confirmed by the Kolmogorov-Smirnov testing ($P > 0.05$), and chi-square was tested using the Levene test ($P > 0.05$). Continuous data satisfying a normal distribution and variance chi-square tests were analyzed using repeated-measures one-way analysis of variance (ANOVA). Non-normally distributed continuous and grade variables were analyzed using the Friedman test, and post hoc pairwise comparisons were performed using the multiplicity-adjusted Dunn test. All tests were two-tailed, and significance was set at $P < 0.05$. All continuous data was presented as mean ± SD, and the grade variable as median (Q1, Q3).

3. Results

The mean age of the female participants was 25.03 ± 0.24 (range, 23–28) years. A representative case is highlighted in Fig. 3, displaying the initial eyelash and the changes at 1 h, 1 day, 1 week, and 1 month after eyelash extension. Table 1 presents the changes in clinical parameters and symptoms at different time points before and after eyelash extension.

The OSDI scores were not statistically different between baseline and 1 week and 1 month after eyelash extension ($P > 0.05$). Additionally, 1 h after eyelash extension, 27 (84.44 %) participants experienced eye symptoms, with the most common symptom being foreign body sensation (59.38 %) (Fig. 4). Other symptoms included sensation of shading (46.88 %), itching (40.63 %), heaviness of the eyelids (15.63 %), and pain (6.25 %). Most symptoms (74.7 %) disappeared within 1 week. Four participants missed the vascular density test due to OCTA equipment malfunction. The OCTA data of the four participants were excluded and only the remaining subject data was analyzed. There were no statistically significant differences in nasal vessel density, temporal vessel density, and ocular redness index between baseline and 1 h, 1 day, 1 week, and 1 month after eyelash extension ($P > 0.05$).

TMH differed significantly between baseline and 1 h, 1 day, 1 week, and 1 month after eyelash extension ($\chi^2 = 27.8$, $P < 0.001$). TMH was highest at 1 h after eyelash extensions at 0.29 ± 0.07 mm, whereas it was lowest at 1 week at 0.24 ± 0.08 mm. Notably, TMH at 1 month after eyelash extensions was 0.25 ± 0.06 mm, which did not return to the baseline level of 0.27 ± 0.08 mm. Further two-by-two comparisons between the groups showed statistical differences between 1 h and baseline, 1 d, 1 week, and 1 month ($P = 0.02$, $P < 0.001$, $P < 0.001$, $P < 0.001$, $P < 0.001$, respectively) (Fig. 5A).

FTBUT and ATBUT decreased at different time points after eyelash extension compared to baseline. Interestingly, NITBUT was similar to TMH, and both also decreased to a minimum at 1 week, with 8.36 ± 4.6 s and 10.71 ± 4.99 s. Similarly, 1 month after eyelash extension, neither FTBUT nor ATBUT reached baseline levels. Statistical differences between FTBUT and ATBUT were found at 5-time points ($\chi^2 = 12.83$, $P = 0.012$; $\chi^2 = 13.70$, $P = 0.008$). In further two-by-two comparisons between groups, FBUT was statistically different only between 1 week after eyelash extension and baseline ($P = 0.03$); ATBUT was statistically different between 1 week after eyelash extension and baseline ($P = 0.018$) and between 1 week and 1 h ($P = 0.023$) (Fig. 5B and C).

There was no statistically significant difference between the Meiboscore and ICU at baseline and 1 h, 1 day, 1 week, and 1 month after eyelash extension ($P > 0.05$). Notably, ICU at 1 h after eyelash extensions was the lowest at 49.25 ± 17.63.

Table 1
Clinical measurements and OSDI scores at baseline and at different time intervals after eyelash extension.

	baseline	1 h	1 day	1 week	1 month	*p*-Value
OSDI score	11.02 ± 12.24	–	–	12.73 ± 11.23	11 ± 10.35	0.161
Nasal vascular density (%)	57.03 ± 4.86	58.41 ± 6.09	56.68 ± 5.48	58.18 ± 5.59	56.32 ± 6.37	0.083
Temporal vascular density (%)	57.67 ± 6.01	56.59 ± 4.79	58.6 ± 4.88	56.1 ± 4.29	55.11 ± 5.63	0.081
TMH (mm)	0.27 ± 0.08	0.29 ± 0.07	0.25 ± 0.08	0.24 ± 0.08	0.25 ± 0.06	<0.001*
FTBUT (s)	9.06 ± 4.7	8.61 ± 4.4	8.36 ± 4.6	6.3 ± 2.69	7.1 ± 3.28	0.012*
ATBUT (s)	11.91 ± 4.86	11.21 ± 4.89	10.71 ± 4.99	8.61 ± 3.61	9.56 ± 3.61	0.008*
Bulbar redness	0.51 ± 0.16	0.53 ± 0.16	0.50 ± 0.17	0.48 ± 0.2	0.49 ± 0.19	0.164
meiboscore	3 (2, 3.25)	2.5 (2, 3)	3 (2, 3)	2.5 (2, 3)	3 (2, 4)	0.336
ICU	56.16 ± 18.53	49.25 ± 17.63	55.25 ± 20.32	56.59 ± 18.75	54.22 ± 20.92	0.175
Corneal staining score	0.09 ± 0.3	0.88 ± 1.39	0.28 ± 0.58	0.28 ± 0.52	0.25 ± 0.44	0.001*

OSDI, Ocular Surface Disease Index; TMH, tear meniscus height; FTBUT, first tear break-up time; ATBUT, average tear break-up time; ICU, interference color units. Data are presented as mean ± SD, median (Q1, Q3), Asterisks denote statistically significant differences ($P < 0.05$).

The corneal staining score increased from 0.09 ± 0.3 (at baseline) to 0.88 ± 1.39 (1 h after lash extension). Corneal staining scores decreased at 1 day, 1 week, and 1 month after eyelash extension compared to 1 h after the procedure, with 0.28 ± 0.58, 0.28 ± 0.52, and 0.25 ± 0.44, respectively. Corneal staining 1 h after eyelash extension was most often located in the inferior region (Fig. 6B); only one participant had corneal staining that was temporally superior in location and had the highest corneal staining scores (Fig. 7C). There was a statistically significant difference in the corneal spotting scores between the time points ($\chi2 = 19.77$, $P = 0.001$). Further two-by-two comparisons between groups revealed a statistically significant difference between baseline and 1 h after eyelash extension ($P = 0.04$) (Fig. 5D).

4. Discussion

This study demonstrated that eyelash extensions may cause ocular surface changes, including corneal epithelial defects and decreased tear

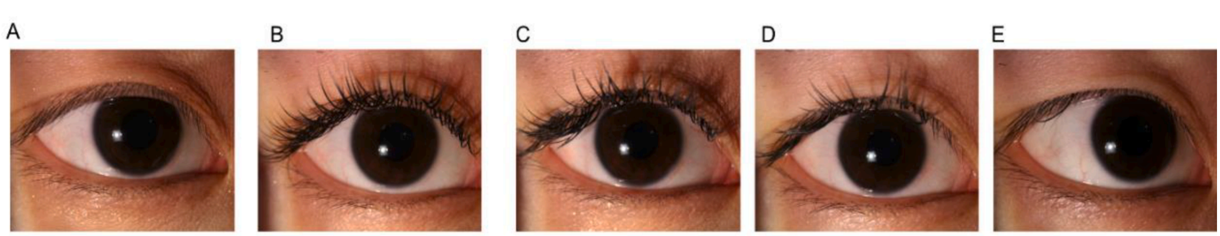

Fig. 3. Representative pictures of eyelash extension participants at several study intervals. A. Pre-study photo. B. One hour after eyelash extension. False eyelashes are thick and curly. C. One day after eyelash extension. D. One week after eyelash extension. False eyelashes are partially shed but still curled. E. One month after eyelash extension. Most of the false eyelashes fall off and the false lashes are couched.

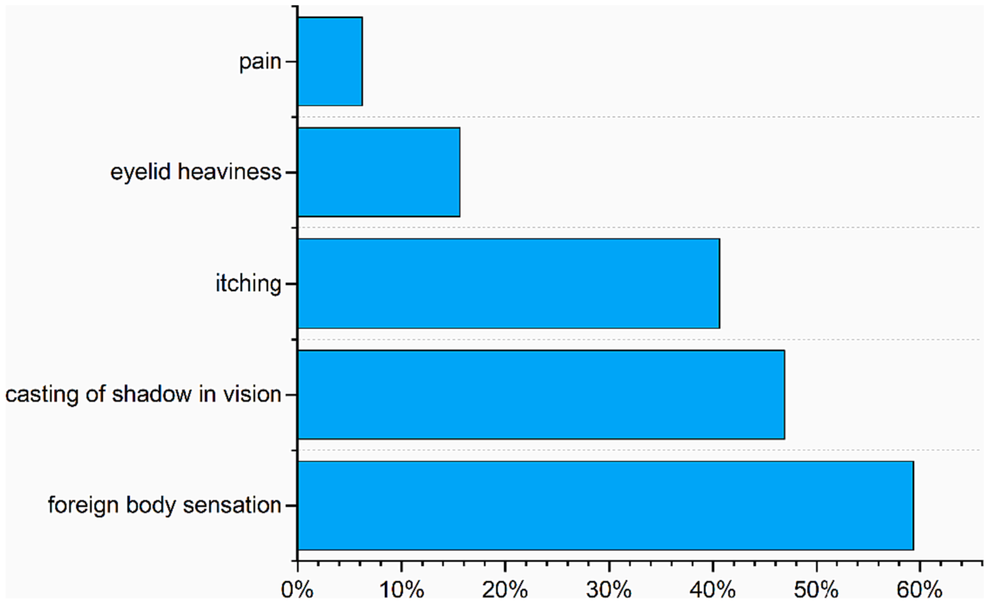

Fig. 4. Symptoms in participants 1 h after eyelash extensions. A participant may experience one or more symptoms.

film stability. This is the first prospective study on the effects of eyelash extension on the ocular surface.

The number of eyelashes was approximately 90 –160 in the upper eyelid and 75–80 in the lower eyelid [11]. Therefore, the number of false eyelash extensions on the upper lid is approximately 120. Eyelashes length varies from 8 to 12 mm in the upper eyelid and 6 –8 mm in the lower eyelid [11]. The natural life cycle of eyelashes involves three phases: anagen, catagen, and telogen, with cycles of 1–2 months, 15 days, and 4–9 months, respectively [1]. On a daily basis, individuals shed one to four eyelashes, and subsequently replace them [2]. When eyelash extensions are applied, false lashes can interfere with normal eyelash shedding and the growth cycle. Eyelashes have a dense array of sensory terminals that are believed to be crucial in triggering the blink reflex, thereby protecting the cornea [12]. Additionally, these eyelashes have sebaceous glands (Zeis glands) to maintain lubrication and elasticity but lack erector pilori muscles [13]. Racial differences exist in eyelash shape and length. Na et al., [14] studied the eyelashes of 10 Caucasian and 20 Asian (Korean) women aged 20–29 years; compared with Caucasians, Asian eyelashes showed lower lift-up and curl-up angles, fewer numbers, and a thicker transverse diameter. Another study [15] rated the attractiveness of female Indian, Asian, Black, and White faces with varying eyelash lengths and found that the most attractive eyelashes for Black women were skewed toward a greater eyelash-length to eye-width ratio compared to that in the other images. Therefore, this variation contributes to the diverse the style and length of false eyelashes observed across different countries.

The predominant symptom in this study was foreign body sensation. The reason for foreign body sensation may be, on the one hand, a corneal punctate epithelial defect due to glue irritation and other reasons; on the other hand, it may be due to corneal dryness caused by the manual fan for cooling the glue. In addition, false eyelashes increase the burden on the muscles around the eyelids. This may cause heavy eyelids. Symptoms are usually alleviated after a period of adaptation and repair of the ocular surface. Therefore, after 1 week, the symptoms disappeared in most participants. Hence, the OSDI scores after 1 week of eyelash extension were only mildly elevated. Studies have demonstrated that the significant complications of eyelash extension are contact dermatitis and delayed hypersensitivity reactions to the glue used for eyelash application [16]. However, these complications were not observed in this study. The main reason for obtaining eyelash extensions was beauty reasons [6]. Eyelash extensions come in various colors, shapes, and styles and can be designed to enlarge the eyes depending on the eye shape. Eyelash extensions last longer (weeks to months) than regular false eyelashes. During this time, eyelash curlers and mascara can be skipped. Therefore, the makeup time can be shortened considerably. For these reasons, most people choose to obtain extensions again, even if they experience considerable discomfort.

The eyelash glue used in this study was cyanoacrylate glue (ethyl cyanoacrylate), which is volatile, and the volatile gas has weak lacrimogenous properties [4]. This explains the highest TMH at 1 h after eyelash extensions. Cyanoacrylates, such as ethyl cyanoacrylate, are used in instant glues for industrial and household purposes and wound adhesives in health care [4,17]. The ICU had the lowest values 1 h after eyelash extension, and the transient decrease in the ICU may have been caused by excessive tear production. Increasing the eyelash length from zero to the optimal length effectively reduces water evaporation, regardless of the direction of air intake and eyelash orientation. However, a further increase in the eyelash length can lead to enhanced evaporation. The optimal eyelash length was approximately 15–30 % of the eye width for the normal and parallel inlet air directions [18]. An increased eyelash length because of eyelash extension leads to increased tear evaporation. This may be the reason for the decrease in TMH one day after eyelash extensions.

Both FTBUT and ATBUT were minimized 1 week after eyelash extensions. Simultaneously, the height of the TMH decreased to a minimum, and the OSDI scores increased. This indicates that the participants had the worst tear film stability 1 week after eyelash extension. As the false eyelashes were still thicker and longer at 1 week, tear evaporation increased, leading to a decrease in tear film stability [19,20], which caused an increase in OSDI scores. However, 1 month after eyelash extension, tear film stability did not return to baseline levels. This implies that the participants require a longer period to restore ocular surface homeostasis. If continuous eyelash extensions are required, an interval over 1 month is recommended. Alternatively, artificial tears may be used after eyelash extensions to replenish the evaporated excess tears. The ICU and meiboscore did not show statistical differences across the time intervals studied, indicating that eyelid extensions may not affect the meibomian glands in the short term. In addition, there were no significant differences in ocular redness index or vascular density, suggesting that eyelid extension may not produce significant inflammatory changes [21].

In most participants, corneal staining primarily involved the lower

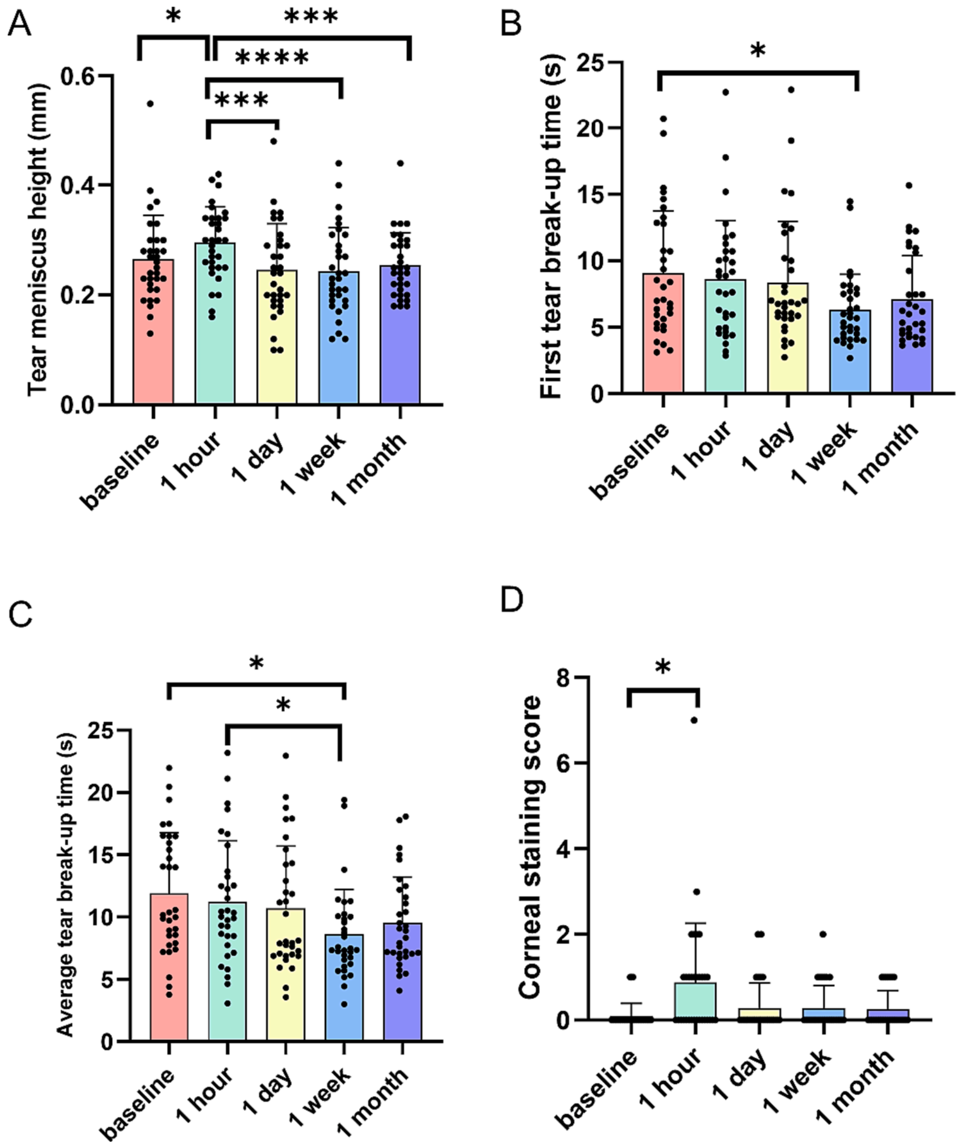

Fig. 5. Effect of eyelash extensions on tear meniscus height (A), first tear break-up time (B), average tear break-up time (C), and corneal staining (D). Each point represents a clinical parameter for a single participant. Bars represent the mean of the clinical parameters, and error bars represent the standard deviation. *=P < 0.05; ***=P < 0.001; ****=P< <0.0001.

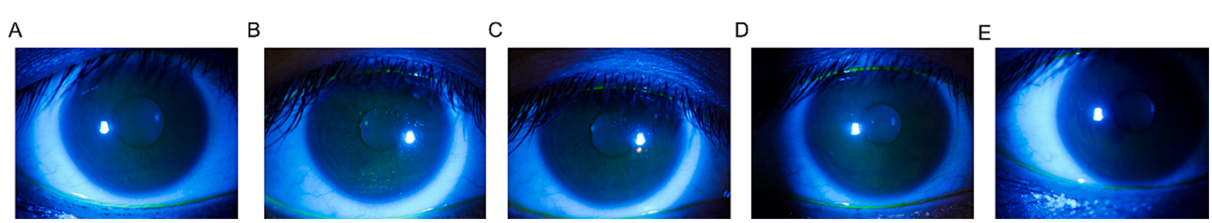

Fig. 6. Representative images of corneal staining at different time intervals in the same participant. A. At baseline, no corneal staining was seen. B. One hour after eyelash extensions, a large area of punctate and short lines of staining were visible in the cornea below. C. One day after eyelash extensions, corneal staining was markedly improved, and several punctate stains were visible below. D. One week after eyelash extensions, a small amount of punctate staining was still visible below. E. One month after eyelash extensions, no significant corneal staining.

regions. Corneal staining may be caused by exposure of the lower cornea due to incomplete eyelid closure during the operation due to self-inflicted causes, excessive lifting of the tape, etc. Similarly, the glue is volatile, and volatile gases enter the eye, which, together with tear kinetics, lead to staining of the lower cornea. However, it is also possible that the eye patch was too high, causing contact with the cornea.

However, this study had some limitations. First, because the use of an external force may alter the natural process of false eyelash shedding, the secretion and characteristics of meibum were not evaluated in this study; second, since this is a pre-post study, the study did not set up a control group; third, the sample size in this study is small, and we will expand it in the future; fourth, there are various types of glues available

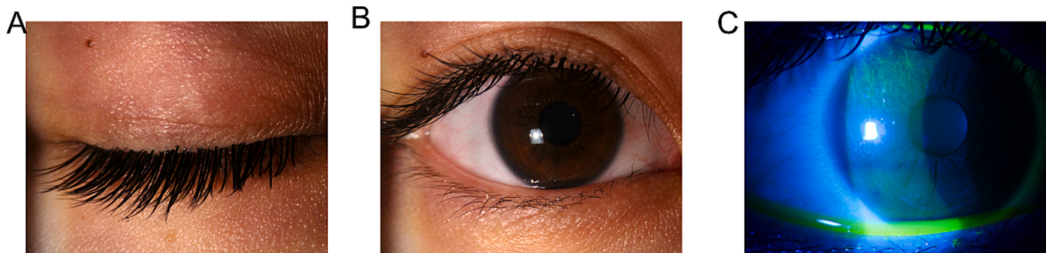

Fig. 7. Images with the highest corneal staining scores 1 h after eyelash extensions. A. Images of eyelashes with eyes closed. B. Images with eyes open. C. Corneal staining Images were obtained using cobalt blue light. Large areas of corneal staining are observed in the supratemporal regions.

on the market, including formaldehyde glues, cyanoacrylate glues, and fibrin adhesive [5]. In addition, only cyanoacrylate adhesives were chosen for this study, which are the most commonly used adhesives today. In the future it could be further explored whether different types of adhesives affect the ocular surface in different ways.

Here, this study followed the effects of eyelash extensions on the ocular surface over a 1-month period. Eyelash extensions were found to affect the ocular surface and cause ocular symptoms such as foreign body sensation, even when a skilled eyelash artist and compliant adhesive were selected. Eyelash extensions particularly affected the tear film, reducing the TMH and decreasing tear film stability.

5. Availability of data and materials

The data supporting the findings of this study are available from the corresponding author, Liang Hu, upon request.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clae.2023.102109.

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