



Dynamic changes in tear film parameters after upper eyelid blepharoplasty measured with anterior segment optical coherence tomography

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ABSTRACT

Background: Upper eyelid blepharoplasty, a corrective procedure for dermatochalasis, may transiently affect eyelid function and tear film stability. This study assessed the effect of upper eyelid blepharoplasty, subjectively through questionnaires, and objectively through tear film stability and production.

Methods: This non-randomized, prospective, interventional study consecutively recruited the right eyes of patients with dermatochalasis who underwent bilateral upper eyelid blepharoplasty at a tertiary center. Preoperative assessments included a standardized ophthalmic examination, ocular surface disease index (OSDI) questionnaire, Schirmer's test I, tear break-up time (TBUT) test, and anterior segment optical coherence tomography (AS-OCT) to measure tear meniscus height (TMH) and tear meniscus area (TMA). Postoperative evaluations were conducted at 1, 3, and 6 months. At the final follow-up, scar quality and patient satisfaction were assessed using the Patient and Observer Scar Assessment Scale.

Results: Fifty eyes of 50 patients with a mean (standard deviation) age of 47.1 (1.6) years were included. Statistically significant postoperative changes were observed in the OSDI score, Schirmer's test value, TBUT, and TMH at the 6-month follow-up (all $P < 0.001$). These parameters initially worsened at 1 month and then improved significantly at 3 and 6 months, returning to or surpassing baseline levels. TMA showed a transient postoperative decline, with full recovery at 6 months. Exceptionally strong positive correlations were found between TMH or TMA and TBUT or the Schirmer's test value at most follow-up visits (all $P > 0.05$). Patient satisfaction was high, with 95% reporting satisfaction with cosmetic outcomes, and no cases of visible or hypertrophic scarring were observed at final follow-up.

Conclusions: We observed significant yet transient changes in tear film parameters and subjective assessments following upper eyelid blepharoplasty. A strong correlation was observed between AS-OCT measurements and parameters of tear film stability and production. High patient satisfaction and favorable cosmetic outcomes, with no visible scarring, further support the safety and tolerability of this procedure. Further studies with larger cohorts, longer follow-up periods, and comparative designs are warranted to validate these findings and further explore the long-term effects on ocular surface health and patient-reported outcomes.

KEYWORDS

blepharoplasties, eyelid, optical coherence tomography, tear, dry eye, data correlation

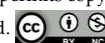
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INTRODUCTION

Dermatochalasis, or redundant upper eyelid skin, is a condition in which the eyelid loses its elasticity and becomes increasingly redundant due to aging, frequent ultraviolet light exposure, or genetic factors. Patients typically experience functional changes including visual field effects and psychological problems [1-3]. Upper eyelid blepharoplasty is a surgical procedure for correcting dermatochalasis by removing the skin and a strip of orbicularis muscle, with or without orbital fat removal. This causes transient impairment of lid functions, affecting normal blinking and tear film stability because of scar formation or injury to the nerve supply of the orbicularis oculi muscle [4-6].

A normal blinking rate maintains tear film distribution and mechanically contributes to meibomian gland secretion; hence, any change in the blinking pattern results in altered tear film parameters and dry eye [7, 8]. Dry eye occurs more frequently when blepharoplasty is performed simultaneously for the upper and lower lids than when performed separately [9]. Moreover, postoperative epiphora is common after blepharoplasty because of eyelid swelling, which may interfere with the normal tear pump mechanism [10]. Upper eyelid blepharoplasty is associated with the release of tear inflammatory cytokines during the postoperative period, including interleukin (IL)-6, IL-8, and tumor necrosis factor- α , in patients with preoperative dry eye. This is associated with postoperative tear film instability, particularly during the early postoperative period [11].

Anterior segment optical coherence tomography (AS-OCT) is an objective, noninvasive, noncontact imaging technique that allows easy and rapid quantitative analysis of anterior segment parameters with little inter-examiner discrepancy and good reproducibility [12, 13]. It can be used to study tear film parameters, including tear meniscus height (TMH) and tear meniscus area (TMA) [14, 15].

This study evaluated tear film parameters after upper eyelid blepharoplasty—objectively, using AS-OCT, Schirmer's test, and the tear break-up time (TBUT) test—and subjectively, using the ocular surface disease index (OSDI) questionnaire and patient satisfaction score.

METHODS

This non-randomized, prospective, interventional study consecutively recruited the right eyes of patients with dermatochalasis who were referred to a tertiary center at the outpatient clinic of Minia University Ophthalmology Hospital, El-Minya, Egypt, and who underwent bilateral upper eyelid blepharoplasty, from March 2022 to April 2023. This study adhered to the Tenets of the Declaration of Helsinki and was approved by the local research ethics committee of the Faculty of Medicine of Minia University, Egypt. All participants provided detailed written informed consent after learning the study details, possible risks, and benefits.

The right eyes of patients aged >18 years with dermatochalasis who were scheduled to undergo bilateral upper eyelid blepharoplasty were included. Patients with a history of eyelid surgery, congenital or acquired eyelid malposition, brow ptosis, or intraocular surgeries; those with a history of ocular surface disease, dry eye disease, or use of topical medications; those with systemic or local comorbidities that may affect tear film parameters or the ocular surface; and those with psychological instability or failure to complete a 6-month follow-up were excluded.

A standardized comprehensive ophthalmic examination of the anterior and posterior segments was conducted before the procedure using a slit-lamp (Topcon SL-D701; Topcon, Tokyo, Japan). An external eye examination, including the eyelids, eyebrows, and periocular area, was performed to assess for other involutional changes, document the appearance and site of the upper eyelid crease, and measure the marginal reflex distance-1. The lid margins, conjunctiva, punctal orifices, and tear meniscus were evaluated using slit-lamp examination.

At baseline assessment, patients were asked about the duration of their condition, history of topical and systemic medication use, and systemic diseases. Dry eye symptoms were evaluated using the OSDI questionnaire. The questionnaire consists of 12 questions, with scores ranging from 0 to 100. Higher scores indicate greater disability [16].

Tear film production was assessed using Schirmer's test 1, which measures basal and reflex tears and is performed without anesthesia. A filter paper strip (Opstrip Schirmer Tear Test Strips, Ophtech Unltd Co., New Delhi, India) is placed within the lower conjunctival fornix, and the eyes are kept open for 5 min. A normal result is >10 mm of Schirmer strip wetting after 5 min, and less than 10 mm of wetting is considered abnormal.

The TBUT test was used to evaluate tear film stability. A small amount of fluorescein dye is instilled into the lower conjunctival sac using a sterile fluorescein strip (BioGlo™, HUB Pharmaceuticals, Rancho Cucamonga, CA, USA) moistened with saline. The tear film is examined using a cobalt blue filter under a slit-lamp. The patient is asked to blink several times to evenly distribute the dye across the corneal surface, then to stop blinking and keep the eyes open, and the tear film on the cornea is carefully observed under a slit-lamp. The examiner measures the time (in seconds) from the last blink to the appearance of the first dry spot or disruption of the tear film. Appearance of the first dry spot after 10 s is considered normal.

A single examiner performed AS-OCT using the FD-OCT system (RTVue, software version 2.7; Optovue Inc., Fremont, CA, USA). Examinations were performed in the early morning (9–11 AM) to avoid diurnal variation, at a temperature of 22°C, with low and indirect airflow to eliminate environmental effects. A vertical 6-mm line at the inferior limbus center was used to scan the lower tear meniscus. TMH and TMA were measured at the junction between the middle of the lower lid and the center of the cornea [14, 15].

A single oculoplastic surgeon performed upper eyelid blepharoplasty as detailed elsewhere [17]. Skin marking, excision, and closure were performed under local anesthesia. A cold compress was applied for 15 min on and 10 min off, repeated over a period of 2 to 4 h.

AS-OCT examination, Schirmer's test 1, the TUBT test, and the OSDI questionnaire were performed preoperatively and at 1, 3, and 6 months postoperatively. At the last follow-up visit, the patient satisfaction score and Patient and Observer Scar Assessment Scale (POSAS) were used to assess the satisfaction index and scar quality, respectively. Satisfaction is graded as 0, 1, 2, or 3: grade 0 if the patient is not satisfied, grade 1 if moderately satisfied, grade 2 if satisfied, and grade 3 if very satisfied [18]. The incisional scar tissue was assessed 6 months postoperatively and is staged as follows: 0 for no scar tissue, 1 for scar tissue observed upon close inspection, 2 for apparent scar tissue, and 3 for marked hypertrophic scar tissue.

Data were analyzed using IBM SPSS Statistics for Windows (version 20.0; IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test was used to assess the normality of data distribution. Qualitative variables are summarized using frequencies and percentages, whereas quantitative variables are described using means and standard deviations or medians, ranges, and interquartile ranges (IQRs). Comparisons across different time points were performed using repeated-measures analysis of variance (ANOVA), followed by post hoc Bonferroni adjustments to account for multiple comparisons. Pearson's correlation coefficient was used to examine the relationships between continuous variables. A *P*-value of less than 0.05 was considered statistically significant.

RESULTS

Fifty eyes of 50 patients with a mean (SD) age of 47.1 (11.6) years (range: 42–68 years) were included. Table 1 lists the mean OSDI scores, Schirmer's test scores, TBUT values, and TMHs at different time points.

Statistically significant variations in the mean OSDI scores were observed throughout the study period ($P < 0.001$). Specifically, the mean OSDI score demonstrated a significant increase at the 1-month postoperative visit compared to the baseline value ($P < 0.001$). However, this was followed by a significant decrease at 3 months relative to the baseline value ($P < 0.001$), and at the 6-month follow-up, the score was comparable to the baseline value ($P > 0.05$). Furthermore, when compared to the 1-month postoperative value, the mean OSDI score showed a significant decline at 3 and 6 months (both $P < 0.001$). Notably, a further significant reduction was detected at 6 months in comparison to the 3-month value ($P < 0.001$) (Table 1).

Statistically significant variations in the mean Schirmer's test value were observed throughout the study period ($P < 0.001$) (Figure 1 and Table 1). Specifically, the mean Schirmer's test value demonstrated a significant decrease at the 1-month postoperative visit compared to that at baseline ($P < 0.001$). However, this was followed by a significant increase at 3 months relative to baseline ($P < 0.001$), and at the 6-month follow-up, the score was comparable to the baseline value ($P > 0.05$). Furthermore, when compared to the 1-month postoperative value, the mean Schirmer's test value showed a significant increase at 3 and 6 months (both $P < 0.001$). Notably, a further significant increase was detected at 6 months in comparison to the 3-month value ($P < 0.001$) (Table 1).

Statistically significant variations in the mean TBUT value were observed throughout the study period ($P < 0.001$) (Figure 2 and Table 1). Specifically, the mean TBUT value demonstrated a significant decrease at the 1-month postoperative visit compared to that at baseline ($P < 0.001$). However, this was followed by a significant increase at both 3 ($P < 0.001$) and 6 months ($P < 0.05$) compared to those at baseline.

Furthermore, when compared to the 1-month postoperative value, the mean TBUT value showed a significant increase at 3 and 6 months (both $P < 0.001$). Notably, a further significant increase was detected at the 6-month visit compared to the 3-month visit ($P < 0.001$) (Table 1).

Regarding the AS-OCT findings (Figure 3), statistically significant variations in the mean TMH value were observed throughout the study period ($P < 0.001$). Specifically, the mean TMH value demonstrated a significant decrease at the 1-month postoperative visit compared to the baseline value ($P < 0.001$). However, this was followed by a significant increase at 3 months relative to the baseline value ($P < 0.001$), and at the 6-month follow-up, the score was comparable to that at baseline ($P > 0.05$). Furthermore, when compared to the 1-month postoperative value, the mean 3- and 6-month TMH values significantly increased (both $P < 0.001$). Notably, a further significant increase was detected at 6 months in comparison to that at 3 months ($P < 0.001$) (Table 1).

Changes in the TMA measurement (Figures 3 and 4) were not normally distributed; therefore, the medians and IQRs were recorded. The median area decreased from 0.034 (0.024–0.051) mm² preoperatively to 0.03 (0.018–0.042) mm² after 1 month postoperatively, then it increased to 0.033 (0.022–0.045) mm² after 3 months and returned to 0.034 (0.026–0.048) mm² at 6 months (Figure 4). Wilcoxon signed-rank tests showed significant differences between the preoperative measurement and the 1- and 3-month values (both $P < 0.001$); however, no differences were observed at 6 months ($P = 0.509$). Significant differences were also found between the value at 1 month and those at 3 and 6 months (both $P < 0.001$), and between the 3- and 6-month values ($P < 0.001$).

We observed an exceptionally strong positive correlation of TMH or TMA with TBUT or Schirmer's test value at most time points (all $P < 0.05$) (Table 2). Regarding POSAS, 85% of participants were very satisfied, 10% were satisfied, 3% were moderately satisfied, and 2% were unsatisfied with their postoperative appearance. At the final postoperative visit, two-thirds ($n = 33$, 66%) of the patients had no visible scars along the incision line. The scar was hardly seen in 34% ($n = 17$) of the patients, whereas no patient had a visible or hypertrophic scar (Table 3).

Table 1. OSDI scores and Schirmer's test, TBUT, and TMH values at different time points

Variable	Baseline, Mean $\pm$ SD (Range)	1 month postop, Mean $\pm$ SD (Range)	3 months postop, Mean $\pm$ SD (Range)	6 months postop, Mean $\pm$ SD (Range)	P-value
OSDI score	9.7 $\pm$ 1.3 (7 to 13)	15.1 $\pm$ 1.7 (12 to 18)	10.2 $\pm$ 1.1 (8 to 13)	9.7 $\pm$ 1.3 (6 to 13)	< 0.001
P_0	-	< 0.001	< 0.001	0.284	-
P_1	-	-	< 0.001	< 0.001	-
P_2	-	-	-	< 0.001	-
Schirmer's test (mm)	18.8 $\pm$ 5.1 (12 to 28)	15.6 $\pm$ 4.6 (9 to 25)	17.9 $\pm$ 4.9 (10 to 27)	19.0 $\pm$ 5.1 (11 to 28)	< 0.001
P_0	-	< 0.001	< 0.001	0.875	-
P_1	-	-	< 0.001	< 0.001	-
P_2	-	-	-	< 0.001	-
TBUT (s)	14.1 $\pm$ 2.3 (10 to 18)	12.1 $\pm$ 2.2 (9 to 16)	13.6 $\pm$ 2.1 (10 to 18)	14.4 $\pm$ 2.1 (10 to 18)	< 0.001
P_0	-	< 0.001	0.001	0.029	-
P_1	-	-	< 0.001	< 0.001	-
P_2	-	-	-	< 0.001	-
TMH (μm)	305.1 $\pm$ 60.4 (212 to 394)	274.9 $\pm$ 57.0 (200 to 355)	296.4 $\pm$ 58.5 (209 to 390)	304.3 $\pm$ 58.3 (210 to 391)	< 0.001
P_0	-	< 0.001	0.001	> 0.99	-
P_1	-	-	< 0.001	< 0.001	-
P_2	-	-	-	< 0.001	-

Abbreviations: OSDI, ocular surface disease index; TBUT, tear break-up time; TMH, tear meniscus height; SD, standard deviation; mm, millimeters; s, seconds; μ m, micrometers. Note: P -values < 0.05 are shown in bold; P -values were derived from repeated-measures analysis of variance (ANOVA), followed by post hoc Bonferroni adjustments to account for multiple comparisons. P_0 : Comparison between preoperative and each postoperative time point; P_1 : Comparison between 1-month and 3- or 6-month postoperative time points; P_2 : Comparison between 3- and 6-month postoperative time points.

Table 2. Correlations between the TMH or TMA with TBUT or Schirmer's test value at different time points

Time point	Variable	TMH		TMA	
		Correlation Coefficient	P-value	Correlation Coefficient	P-value
Baseline	TBUT	$r = +0.97$	< 0.001	$r = +0.96$	< 0.001
	Schirmer test	$r = +0.97$	< 0.001	$r = +0.97$	< 0.001
1 month postop	TBUT	$r = +0.95$	< 0.001	$r = +0.91$	< 0.001
	Schirmer test	$r = +0.96$	< 0.001	$r = +0.94$	< 0.001
3 months postop	TBUT	$r = +0.92$	< 0.001	$r = +0.45$	0.001
	Schirmer test	$r = +0.96$	< 0.001	$r = +0.43$	0.002
6 months postop	TBUT	$r = +0.95$	< 0.001	$r = +0.95$	< 0.001
	Schirmer test	$r = +0.97$	< 0.001	$r = +0.96$	< 0.001

Abbreviations: TMH, tear meniscus height; TMA, tear meniscus area; TBUT, tear break-up time; postop, postoperative. Note: P-values < 0.05 are shown in bold.

Table 3. Postoperative scar staging using the Patient and Observer Scar Assessment Scale (POSAS) [18]

Scar stage	n (%)
0: No scar tissue along the incision line	33 (66)
1: Scar tissue can be seen upon close inspection	17 (34)
2: Scar tissue is apparent	0 (0)
3: Marked hypertrophic scar	0 (0)

Abbreviations: n, number of patients; %, percentage.

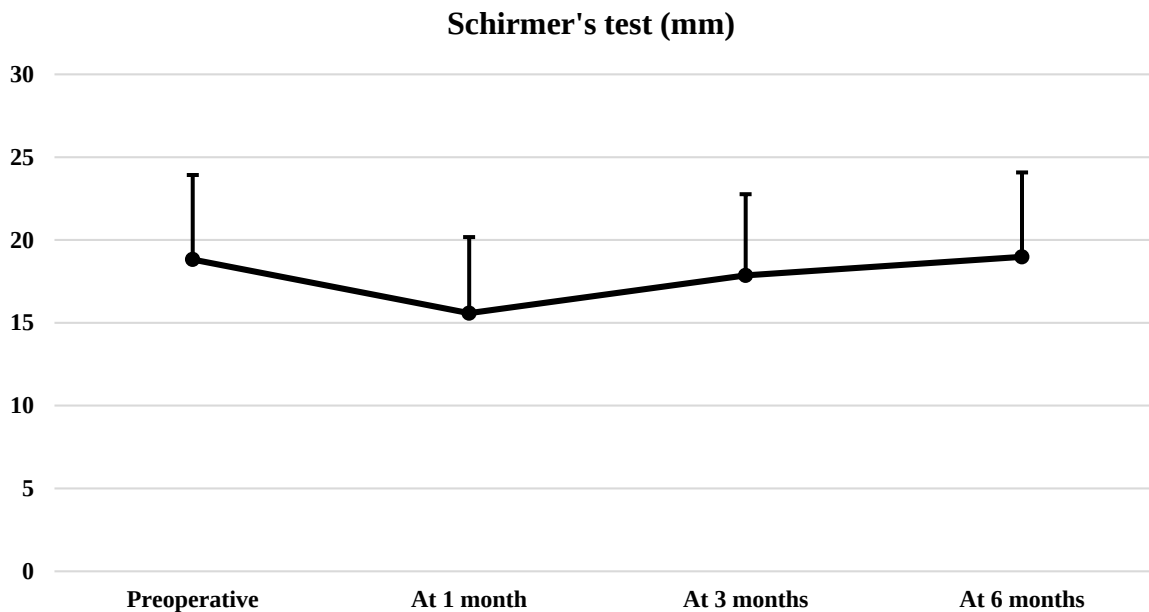


Figure 1. Mean Schirmer's test value in millimeters (mm) recorded at baseline and 1-, 3-, and 6-month postoperative visits following upper eyelid blepharoplasty. Error bars indicate standard deviations. A significant decline was noted at 1 month postoperatively, with subsequent improvement and return to baseline values by 6 months.

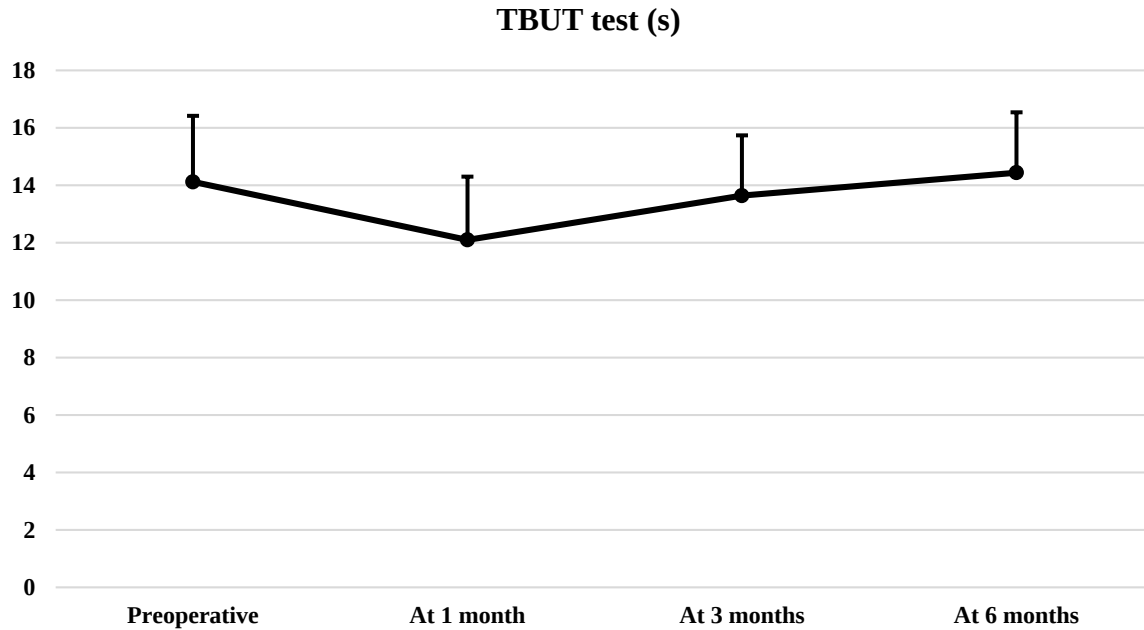


Figure 2. Mean tear break-up time (TBUT) values measured in seconds (s) at baseline and 1-, 3-, and 6-month postoperative visits following upper eyelid blepharoplasty. Error bars represent standard deviations. A significant reduction was observed at 1 month, followed by progressive improvement and return to baseline levels by 6 months.

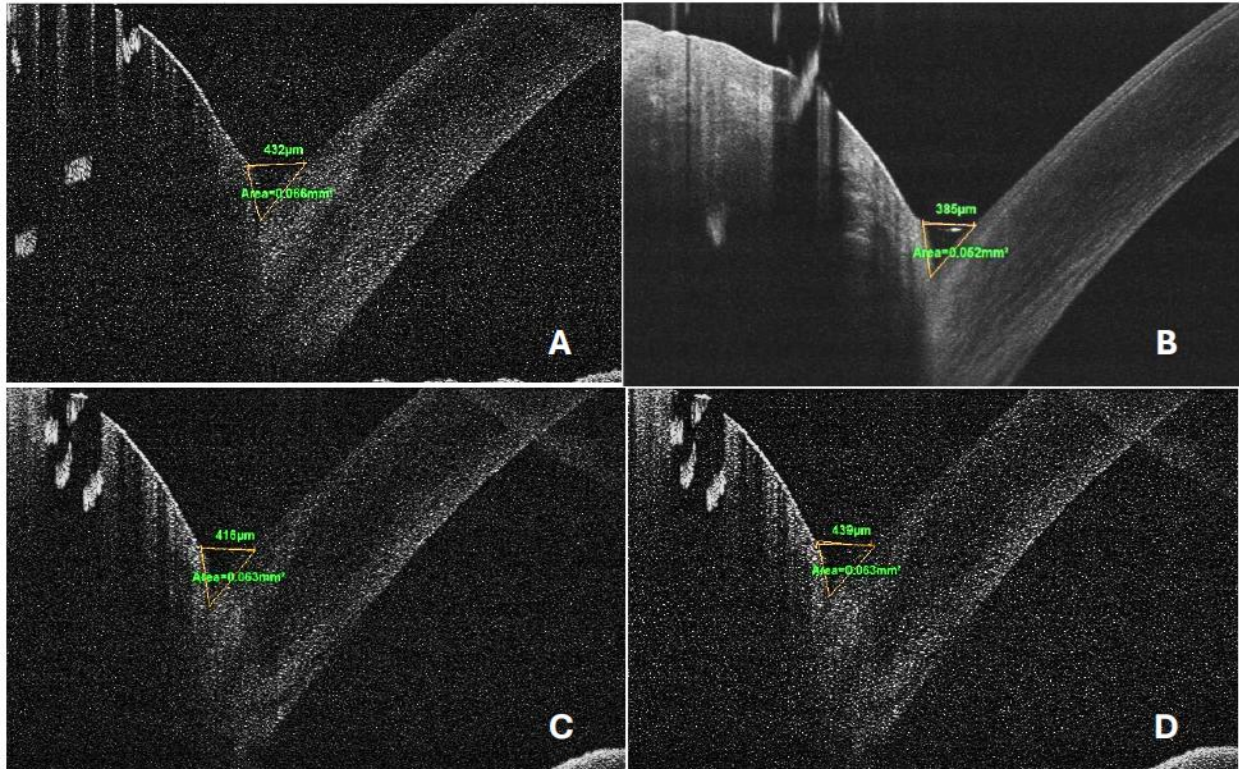


Figure 3. Anterior segment optical coherence tomography (AS-OCT) images of the tear meniscus height and area (TMH in micrometers [μm] and TMA in square millimeters [mm²], respectively) acquired using the FD-OCT system (RTVue, software version 2.7; Optovue Inc., Fremont, CA, USA) in one study participant. (A) Preoperative (TMH = 432 μm and TMA = 0.066 mm²), (B) 1 month postoperative (TMH = 385 μm and TMA = 0.062 mm²), (C) 3 months postoperative (TMH = 415 μm and TMA = 0.063 mm²), and (D) 6 months postoperative (TMH = 439 μm and TMA = 0.063 mm²).

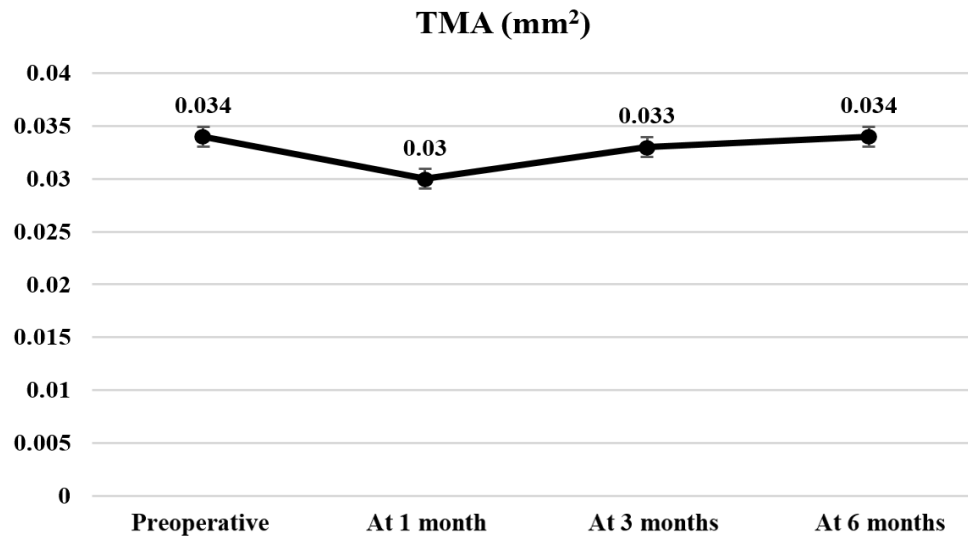


Figure 4. Median tear meniscus area (TMA) measurements in square millimeters (mm²) at baseline and 1-, 3-, and 6-month postoperative visits following upper eyelid blepharoplasty. Error bars represent interquartile ranges. A significant decrease in TMA was observed at 1 month postoperatively, followed by gradual recovery at 3 months and a return to baseline by 6 months. Statistical comparisons were performed using the Wilcoxon signed-rank test.

DISCUSSION

This prospective study revealed transient postoperative changes in tear film parameters after upper eyelid blepharoplasty. Significant alterations were noted at 1 month, with gradual improvement and a return to baseline by 6 months for the OSDI score, Schirmer's test value, TBUT, TMH, and TMA. The objective and subjective metrics were largely aligned, and no lasting impairment or visible scarring was observed. These findings suggest a short-term postoperative tear film disturbance, with functional recovery over time in appropriately selected patients.

Dry eye disease remains a concern after oculoplastic procedures, particularly upper eyelid blepharoplasty. Upper eyelid blepharoplasty is one of the most frequently performed oculoplastic procedures worldwide [19]. Although several retrospective studies have reported an association between blepharoplasty and postoperative dry eye symptoms [20, 21], the causal relationship between upper eyelid blepharoplasty and dry eye disease remains inconclusive [22–26]. In the present study, both the Schirmer's test and TBUT demonstrated significant reductions at 1 and 3 months postoperatively. At the 6-month follow-up, TBUT significantly improved compared to the baseline value, whereas the Schirmer's test value returned to a level comparable to the preoperative measurement. These findings align with those of Shao et al. [9], who reported a transient postoperative decline in Schirmer's test value, followed by recovery to baseline at 3 months [9]. Our results suggest that although transient alterations in tear film parameters may occur following surgery, these changes tend to stabilize or resolve within 6 months.

We observed a significant reduction in TBUT at 1 month, followed by progressive improvement and return to baseline levels by 6 months. Turker and Dogan [27] found an early increase in TBUT 1 week postoperatively, which decreased after 3 months. They observed significantly lower scores on Schirmer's test in their patients at 3 months postoperatively compared with the preoperative measurements [27]. Aygun et al. [22], however, performed Schirmer's test under local anesthesia in patients after upper eyelid blepharoplasty and found no statistically significant differences in the values throughout the follow-up period [22].

In our study, the analysis of tear meniscal parameters revealed a statistically significant decrease in the mean TMH at 1 month postoperatively, followed by progressive increases at 3 and 6 months. Similarly, the median TMA significantly decreased at 1 month, then increased, returning to preoperative values by 6 months. These findings suggest a transient alteration in tear film dynamics following upper eyelid blepharoplasty, with subsequent recovery over time. In contrast, Aydemir and Aksoy Aydemir [28] reported no significant postoperative changes in TMH or TMA after upper blepharoplasty. Notably, their study utilized a Spectralis OCT device (Heidelberg Engineering) and did not involve orbicularis muscle excision during the procedure [28], which may account for the different outcomes.

Our study demonstrated a strongly positive correlation of TMH and TMA with both TBUT and Schirmer's test

measurements across most postoperative time points. These findings are consistent with those of Eroglu et al. [29], who reported significant correlations between structural and functional tear film parameters in healthy individuals [29]. In contrast, another study [15] documented weaker correlations in a cohort of patients with established dry eye disease [15], in whom compensatory mechanisms and baseline abnormalities may obscure these relationships.

In the present study, the mean OSDI score increased significantly by 1 month postoperatively, followed by a gradual decline at 3 months and a return to baseline value by 6 months. This pattern suggests a transient exacerbation of dry eye symptoms that resolves over time. In contrast, Aygun et al. [22] reported a sustained elevation in OSDI score up to 6 months after surgery [22], while Mak et al. [26] observed a significant increase in OSDI score persisting 6–8 months postoperatively [26]. Interestingly, a comparative study [25] evaluating patients who underwent upper blepharoplasty with or without orbicularis muscle excision found no significant differences in OSDI scores, with values normalizing in both groups by 6 months [25].

Based on the POSAS, most patients reported satisfaction with the postoperative appearance of their largely unnoticeable scars. These results align with findings from other studies [30–32], further supporting the aesthetic efficacy of the surgical technique used in this cohort and validating its effectiveness in minimizing visible scarring.

This study used validated tools and serial assessments to provide both objective and subjective insights into postoperative tear film dynamics following upper eyelid blepharoplasty. Notable strengths include the prospective design, standardized surgical technique, and comprehensive multimodal evaluation, particularly the incorporation of AS-OCT. However, the study is limited by its non-randomized design, inclusion of a single eye per participant, and the absence of noninvasive TBUT, ocular surface staining, and tear film osmolarity, which may limit the generalizability of the findings. Additionally, the relatively small sample size warrants caution. Further studies with larger cohorts, extended follow-up periods, and randomized controlled designs are needed to fully characterize the long-term effects of upper lid blepharoplasty on ocular surface integrity and tear film physiology.

CONCLUSIONS

This study demonstrates that upper eyelid blepharoplasty may induce transient changes in both subjective and objective tear film parameters, including OSDI, Schirmer's test value, TBUT, TMH, and TMA, with most values returning to baseline by 6 months postoperatively. The observed improvements in tear metrics after the early postoperative period suggest that the effect on ocular surface function is temporary. Patient-reported satisfaction was high, and no significant long-term scarring was observed. These findings support the short-term safety of the procedure. However, additional studies with larger cohorts and extended follow-up are necessary to confirm these results and gain a deeper understanding of the long-term outcomes.

ETHICAL DECLARATIONS

Ethical approval: This study adhered to the Tenets of the Declaration of Helsinki and was approved by the local research ethics committee of the Faculty of Medicine of Minia University, Egypt. All participants provided detailed written informed consent after learning the study details, possible risks, and benefits.

Conflict of interest: None.

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