Skin-Only Versus Skin-Plus-Orbicularis Resection Blepharoplasty: An Elaborated Analysis of Early- and Long-Term Effects on Corneal Nerves, Meibomian Glands, Dry Eye Parameters, and Eyebrow Position

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Purpose: To evaluate the early- and long-term effects of 2 different blepharoplasty techniques on corneal nerves, meibomian gland morphology, clinical parameters of dry eye disease (DED), and eyebrow position.

Methods: This prospective, interventional study included age-sex-matched blepharoplasty patients who had a skin-only resection (24 eyes of 12 patients; Group-S) or a skin-plus-orbicularis muscle resection (24 eyes of 12 patients; Group-M) procedure. Preoperative and postoperative parameters of in vivo corneal confocal microscopy (IVCCM; corneal nerve fiber density [CNFD], nerve branch density [CNBD], and nerve fiber length), meibomian gland area loss (MGAL), DED (Schirmer I test and noninvasive tear breakup time), and eyebrow heights (lateral [LBH] and central [CBH]) were evaluated and compared between the intervention groups (ClinicalTrials.gov, NCT05528016).

Results: Compared with baseline, the CNBD of Group-S (19.91 ± 7.66 vs. 16.05 ± 7.28 branches/mm^2, p = 0.049) and CNFD of Group-M (19.52 ± 7.45 vs. 16.80 ± 6.95 fibers/mm^2, p = 0.028) was significantly decreased at postoperative first week. However, in both groups, IVCCM parameters returned to baseline values at postoperative first month and first year (p > 0.05). A significant MGAL increase was observed in Group-S (18.47 ± 5.43 vs. 19.94 ± 5.31, p = 0.030) and Group-M (18.86 ± 7.06 vs. 20.12 ± 7.01, p = 0.023) at the postoperative first year, demonstrating meibomian gland atrophy. Only significant changes were observed in Group-M in LBH (16.17 ± 2.45 vs. 16.67 ± 2.28 mm, p = 0.044) and CBH (17.33 ± 2.35 vs. 17.96 ± 2.31 mm, p = 0.004) at postoperative first year.

Conclusions: Blepharoplasty with or without orbicularis resection seems to have similar effects on IVCCM, DED, and MGAL parameters. However, incorporating an orbicularis muscle resection in a blepharoplasty operation could slightly elevate the eyebrow position.

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Upper blepharoplasty is among the most commonly performed cosmetic surgeries.[1] In addition, it is one of the primary functional surgeries in the oculoplastic surgery field due to peripheral vision loss caused by dermatochalasis. It has become a reliable surgical procedure with many methods, high satisfaction, and low complication rates.

For upper eyelid blepharoplasty, methods such as excision of excess skin only[2] and resection of the orbicularis oculi muscle, along with the skin and fat pads, have been described.[3] The primary purposes of removing the preseptal orbicularis oculi underlying the skin are to provide a more prominent lid crease, reduce the appearance of fullness in the lid, and raise the eyebrow level by orbicularis oculi muscle recruitment, which is one of the depressors of the eyebrows. The effects of these 2 surgical methods on eyebrow height are considered exciting topics in the literature.[4,5] In addition, while some authors claim that the skin and muscle removal method provides better cosmetic results,[6,7] others state that protecting the orbicularis oculi muscle is preferable for maintaining the fullness of the upper eyelid, which indicates a youthful appearance.[8,9] Although debates about cosmetic results remain, few studies in the literature report on these 2 surgical methods' early- and long-term effects on the ocular surface.[9–13]

Dry eye disease (DED) is one of the most common complications of blepharoplasty, and it has been reported at rates of up to 26.5% (12.9% for the upper lid only).[11] However, the mechanisms behind the development of DED after blepharoplasty remain unclear. Potential causes, such as impairment of

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The Institutional Review Board of Marmara University School of Medicine approved the study protocol with the 09.2022.102 protocol number. The procedures used in this study adhered to the tenets of the Declaration of Helsinki.

This study was retrospectively registered at ClinicalTrials.gov (NCT05528016—September 01, 2022).

The data supporting the study findings are available from the corresponding author upon request.

All authors contributed to the study's conception and design. B.Ş. and V.D. performed material preparation and data collection. V.D., M.O.S., and S.A.T. performed analysis and interpretation of data. V.D. wrote the first draft of the manuscript and all authors commented on previous versions. All authors read and approved the final manuscript.

B.Ş. is deceased (August 13, 2022).

Informed consent was obtained from all participants included in the study. In addition, patients signed informed consent regarding publishing their data and photographs.

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lacrimation, increased evaporation due to lagophthalmos, and lipid deficiency in the tear layers resulting from insufficient meibomian gland secretion due to incapacitated blinking, are thought to play a role in the development of postsurgical DED.[14] Thus, studies evaluating blink rate and speed by videographic methods,[15–17] noninvasive tear breakup time (NI-TBUT),[10,12] and tear lipid layer thickness after blepharoplasty have already been published in the literature.[13] Especially tear film instability is considered the key mechanism. Therefore, evaluation of meibomian gland morphology may help elucidate this pathogenesis.

Another issue is the corneal nerve morphology to understand the potential mechanism of postoperative DED. In vivo corneal confocal microscopy (IVCCM) can provide rapid, noninvasive, high-resolution in vivo images to evaluate the corneal subbasal nerve plexus. Therefore, it is used to assess many ophthalmic diseases, including DED, which is known to affect the corneal nerves.[18] In addition, it was reported that exposure to environmental dry eye stress resulted in a significant decrease in subbasal nerve density.[19] Environmental stress can induce ocular surface inflammation due to the secretion of chemical mediators from keratoconjunctival epithelial cells and keratocytes, damaging corneal nerves.[20] In addition, blepharoplasty can affect the eyelid closure and position by causing postoperative periorbital swelling, which disrupts the close relationship between the eyelid, tear film, and ocular surface.[14] In addition, it increases the eyelid pressure, which has been shown to be related to DED.[21] However, to our knowledge, there is no published study evaluating the effect of upper eyelid blepharoplasty on the corneal nerves and meibomian gland morphology to elucidate the mechanism of postoperative blepharoplasty-related DED.

Therefore, the primary objectives of this study are to investigate and compare the early- and long-term effects of skin-only and skin-plus-orbicularis oculi resection upper eyelid blepharoplasty techniques on the corneal subbasal nerve plexus and meibomian gland morphology that may have an impact on postoperative DED and to evaluate their relationship with the most commonly used DED parameters. The secondary objective is to assess the effect of these 2 surgical methods on eyebrow position.

MATERIALS AND METHODS

This interventional, prospective, and longitudinal study was carried out at Marmara University School of Medicine, Department of Ophthalmology, between September 2021 and September 2022. The study was designed with the approval of the Ethics Committee on Human Research of Marmara University School of Medicine and was conducted following the tenets of the Declaration of Helsinki. Written informed consent was obtained from all patients after receiving information about the procedure and the postoperative course. The study was retrospectively registered at ClinicalTrials.gov on September 01, 2022 (NCT05528016).

The study included 48 eyes of 24 patients applied to our clinic's Oculoplastic and Orbital Surgery Unit due to dermatochalasis and were suggested upper eyelid blepharoplasty for medical or cosmetic purposes. The patients were divided into skin-only (Group-S) and skin-plus-orbicularis oculi muscle (Group-M) resection groups according to the applied blepharoplasty techniques at the surgeon's discretion (V.D.). Patients younger than the age of 18, extensive blepharitis, negative Bell's phenomenon, DED (defined as a Schirmer test result of less than 5 mm, tear breakup time of less than 10 seconds, and any corneal fluorescein staining), and with a history of periorbital or ophthalmic surgery, contact lens use, any ophthalmic, endocrinological, neurological, or rheumatological diseases, facial paralysis, and treated with periocular botulinum toxin in the last 1 year were excluded from the study.

Surgical Technique.. All patients were operated on by a single experienced surgeon (V.D.). First, standard upper eyelid blepharoplasty drawings (Fig. 1A) and 15-Gauge scalpel incisions were applied to all patients. Then, the skin excision was performed with Wescott scissors. For patients undergoing orbicularis oculi excision (Group-M), the upper 1/3 of the preseptal orbicularis oculi muscle (3–5 mm) was marked from the medial to the temporal (Fig. 1B). The base of the orbicularis oculi in the temporal region was excised in a triangle shape pointing upwards (Fig. 1C). Next, nasal fat pad excision or coagulation was applied to all patients after minimally opening the septum anterior to the fat pad (Fig. 1D). However, the remaining septum tissue was not damaged in any patients, and the preaponeurotic fat pad was not excised. At the end of the surgery, the skin was closed intracutaneously running fashion with a 6.0 polypropylene suture, and sterile adhesive strips were applied to the wound edges. All sutures were removed at the postoperative first week visit.

Clinical Assessment.. All patients had comprehensive ophthalmological examinations, including best-corrected visual acuity, slit-lamp biomicroscopy, Goldmann applanation tonometry, and dilated fundus examination. In addition, corneal fluorescein staining test, Schirmer I test, IVCCM with Rostock Cornea Module of Heidelberg Retinal Tomography III (Heidelberg Engineering, Heidelberg, Germany), NI-TBUT and meibomian gland area loss (MGAL) measurements with Sirius Scheimpflug-Placido topographer (CSO, Florence, Italy), and central and lateral eyebrow height (CBH and LBH, respectively) measures were evaluated at baseline and postoperative first week, first month, and first year. A single investigator (B.Ş.) blinded to the intervention groups performed all evaluations and data collection.

Before the IVCCM examinations, 2 drops of topical anesthetic (0.5% proparacaine hydrochloride; Alcaine, Alcon-Couvreur, Puurs, Belgium) were applied to both patients' eyes. A 0.2% carbomer-containing gel (Viscotears, Dr. Gerhard Mann, Chem.-Pharm. Fabrik, Berlin, Germany) was used as the coupling agent between the cornea and the applanation cap. Five high-quality, centered images were collected and analyzed from OU of the patients. Automated cornea confocal metrics (ACCMetrics; University of Manchester, Manchester, United Kingdom) corneal nerve fiber analyzer was used to analyze subbasal nerve plexus parameters, including the total number of major nerves per mm^2 (corneal nerve fiber density [CNFD]), the number of branches emanating from major nerve per mm^2 (corneal nerve branch density [CNBD]), and total length of all nerve fibers and branches per mm^2 (corneal nerve fiber length [CNFL]).[22]

Meibomian glands were evaluated on the upper lid tarsus using the Phoenix-Meibography Imaging software (CSO, Florence, Italy) available in the Sirius device. The glands not lined transversely to the tarsal plate were indicated as a "dropout," and the software gave the dropout rate as a percentage. MGAL was defined as the percentage of the area without visible meibomian glands relative to the total tarsal area. The evaluations were performed carefully before the sutures were removed to avoid dehiscence in the wound edges while rotating the upper eyelid.

As DED parameters, corneal fluorescein staining, NI-TBUT evaluation, and Schirmer I test were applied to the patients. The cornea of the patients was stained with fluorescein strips, and any corneal staining on slit-lamp biomicroscopic examination under cobalt blue illumination was recorded. NI-TBUT was determined by the video recording system of the Sirius device by real-time evaluation of Placido disc ring disruption due to tear film breakup without any user intervention. Three measurements were taken after patients blinked twice, and the mean of these measurements in seconds was recorded. Schirmer I test, without any topical anesthetic drops, was performed by placing a strip of sterile paper over the margin of each lower eyelid at the junction of lateral

FIG. 1. Real-time surgical photographs of different patients included in the study analysis. **A**, The drawing of a standard upper eyelid blepharoplasty. **B**, The marking of the orbicularis muscle after the skin excision (note the triangle shape pointing upwards in the temporal region, showing where the orbicularis muscle is to be removed). **C**, The view after the excision of the orbicularis muscle (the septum is intact). **D**, Nasal fat pad excision after minimally opening the septum anterior to the fat pad.

thirds. Five minutes after closing the eyelids, the paper was removed, and the extent of wetting was measured in millimeters.

Open-access Image J software (National Institutes of Health, Bethesda, Maryland, U.S.A.) was used to measure eyebrow positions from patient photos. The horizontal central white-to-white (iris) line was set to 11 mm for the known distance in all images. The distance from the corneal light reflex to the inferior border of the eyebrow in millimeters was determined as CBH, and the length from the lateral canthus to the lateral eyebrow tail was determined as LBH.

Statistical Analysis.. The sample size was calculated based on the study conducted by Cardigos et al.[23] showing a statistical difference in the density of subbasal nerves of DED patients without Sjögren's Syndrome (n = 62) and healthy controls (n = 20) evaluated with the Neuron J plugin of Image J software (26.3 ± 9.2 and 43.9 ± 12.9 n/mm^2, respectively). Considering these values and the alpha value set to 0.05 with a power of 0.95, a sample size of 10 patients was required. With a drop rate assumption of 20%, 12 patients were decided to be included in each group.

Statistical Package for Social Sciences (SPSS) version 24.0 (IBM Corp., Armonk, NY, U.S.A.) for Macintosh was employed for the statistical analysis. The histogram graphs and Shapiro-Wilk test were used to determine the data distribution. Categorical and continuous parametric data were compared with the Pearson chi-square test and independent samples *t* test, respectively. While categorical data were presented as n (percentage), parametric data were given as mean ± standard deviation. A 1-way repeated measures analysis of variance (ANOVA) test followed by Bonferroni correction was conducted to compare the within-group differences. Since the assumption of sphericity assessed with Mauchly's test of sphericity did not meet in the evaluated data, the Greenhouse and Geisser test was used to correct the 1-way repeated measures ANOVA. A *p*-value of less than 0.05 was considered statistically significant, and *p*-values adjusted with Bonferroni correction were given where appropriate.

RESULTS

Twenty-four eyes of 12 patients in both groups, with a mean age of 53.2 ± 10.4 in Group-S and 51.2 ± 9.6 years in Group-M, were included in the study ($p = 0.512$). There were 9 (75%) and 11 (91.7%) females in Group-S and Group-M, respectively ($p = 0.121$). At the baseline evaluation, there were no significant differences between the study groups regarding CNFD ($p = 0.430$), CNBD ($p = 0.936$), CNFL ($p = 0.968$), Schirmer I ($p = 0.183$), NI-TBUT ($p = 0.460$), MGAL ($p = 0.924$), CBH ($p = 0.403$), and LBH ($p = 0.875$) (Table 1).

IVCCM evaluation of subbasal nerve plexus in Group-S revealed a significant decrease only in postoperative first week CNBD (16.05 ± 7.28 branches/mm^2) compared with baseline (19.91 ± 7.66 branches/mm^2, $p = 0.049$), which was significantly increased and returned to the values comparable with baseline at postoperative first month (21.47 ± 8.85 branches/mm^2, p = 0.022 compared with postoperative first week, and p = 1.000 compared with baseline) and remained similar to baseline at postoperative first year (17.25 ± 7.61, p = 0.914 compared with baseline), $F(2.38, 54.82)$ = 4.05, p = 0.017 (Table 1 and Fig. 2B). Among the nerve plexus parameters in Group-M, a significant decrease was observed only in postoperative first week CNFD (16.80 ± 6.95 fibers/mm^2) compared with baseline (19.52 ± 7.45 fibers/mm^2, p = 0.028), which was significantly increased and returned to the values comparable with baseline at postoperative first month (20.20 ± 8.37 fibers/mm^2, p = 0.038 compared with postoperative first week, p = 1.000 compared with baseline) and remained similar to baseline at postoperative first year (18.59 ± 6.90 fibers/mm^2, p = 1.000 compared with baseline), $F(2.56, 58.86)$ = 3.46, p = 0.028 (Table 1 and Fig. 2A). All other subbasal nerve plexus parameters also tended to decrease at the postoperative first week and increase and remain

TABLE 1. Baseline and postoperative evaluations of skin-only (Group-S) and skin-plus-orbicularis (Group-M) blepharoplasty patients

Parameters		Postoperative			One-way repeated measures ANOVA*			Post hoc test†	
Mean ± SD	Baseline (a)	First week (b)	First month (c)	First year (d)	F	df	p		
Group-S									
CNFD, fibers/mm^2	18.03 ± 5.34	16.93 ± 5.93	19.67 ± 5.38	17.15 ± 6.48	2.56	2.39, 55.03	0.077	—	—
CNBD, branches/mm^2	19.91 ± 7.66	16.05 ± 7.28	21.47 ± 8.85	17.25 ± 7.61	4.05	2.38, 54.82	**0.017**	a vs. b, p = **0.049** a vs. c, p = 1.000 a vs. d, p = 0.914	b vs. c, p = **0.022** b vs. d, p = 1.000 c vs. d, p = 0.439
CNFL, mm/mm^2	12.43 ± 2.70	11.64 ± 3.13	12.60 ± 2.87	11.31 ± 2.90	2.12	2.79, 64.21	0.111	—	—
NI-TBUT, seconds	13.22 ± 4.45	12.17 ± 3.87	12.78 ± 3.68	12.21 ± 4.59	0.54	2.46, 56.58	0.624	—	—
Schirmer I, mm	11.50 ± 3.69	11.04 ± 3.47	11.42 ± 3.83	11.58 ± 3.97	0.47	1.66, 38.23	0.594	—	—
MGAL, %	18.47 ± 5.43	18.51 ± 5.20	18.91 ± 5.53	19.94 ± 5.31	9.32	1.47, 33.76	**0.002**	a vs. b, p = 1.000 a vs. c, p = 0.209 a vs. d, p = **0.030**	b vs. c, p = 0.228 b vs. d, p = **0.005** c vs. d, p = 0.055
CBH, mm	16.75 ± 2.43	16.71 ± 2.56	16.92 ± 2.39	16.83 ± 2.55	1.00	2.32, 53.29	0.384	—	—
LBH, mm	17.04 ± 2.44	17.08 ± 2.52	17.41 ± 2.61	17.29 ± 2.44	1.68	2.49, 52.38	0.191	—	—
Group-M									
CNFD, fibers/mm^2	19.52 ± 7.45	16.80 ± 6.95	20.20 ± 8.37	18.59 ± 6.90	3.46	2.56, 58.86	**0.028**	a vs. b, p = **0.028** a vs. c, p = 1.000 a vs. d, p = 1.000	b vs. c, p = **0.038** b vs. d, p = 0.987 c vs. d, p = 1.000
CNBD, branches/mm^2	20.12 ± 10.33	17.20 ± 8.92	22.89 ± 15.32	19.54 ± 10.12	2.62	2.61, 59.97	0.066	—	—
CNFL, mm/mm^2	12.47 ± 3.27	11.93 ± 3.03	12.67 ± 3.40	11.64 ± 3.10	2.01	2.41, 55.55	0.135	—	—
NI-TBUT, seconds	14.10 ± 3.72	13.53 ± 3.41	14.00 ± 3.46	13.27 ± 4.07	0.63	2.10, 48.30	0.543	—	—
Schirmer I, mm	13.42 ± 5.87	12.08 ± 6.87	13.17 ± 6.08	12.37 ± 5.29	0.94	1.84, 42.27	0.393	—	—
MGAL, %	18.86 ± 7.06	18.78 ± 7.22	19.43 ± 7.41	20.12 ± 7.01	5.31	2.45, 56.44	**0.005**	a vs. b, p = 1.000 a vs. c, p = 1.000 a vs. d, p = **0.023**	b vs. c, p = 0.276 b vs. d, p = **0.006** c vs. d, p = 0.698
CBH, mm	17.33 ± 2.35	17.54 ± 2.00	17.83 ± 2.12	17.96 ± 2.31	7.89	2.42, 55.56	**<0.001**	a vs. b, p = 1.000 a vs. c, p = **0.028** a vs. d, p = **0.004**	b vs. c, p = **0.032** b vs. d, p = 0.089 c vs. d, p = 1.000
LBH, mm	16.17 ± 2.45	16.33 ± 2.12	16.50 ± 2.04	16.67 ± 2.28	3.80	2.21, 50.74	**0.025**	a vs. b, p = 1.000 a vs. c, p = 0.436 a vs. d, p = **0.044**	b vs. c, p = 0.621 b vs. d, p = 0.345 c vs. d, p = 0.970

Bold values indicate statistical significance.
*Corrected with Greenhouse-Geisser test.
†p values adjusted for multiple comparisons with Bonferroni correction.
ANOVA, analysis of variance; CBH, central brow height; CNBD, corneal nerve branch density; CNFD, corneal nerve fiber density; CNFL, corneal nerve fiber length; LBH, lateral brow height; NI-TBUT, noninvasive tear breakup time; MGAL, meibomian gland area loss; SD, standard deviation.

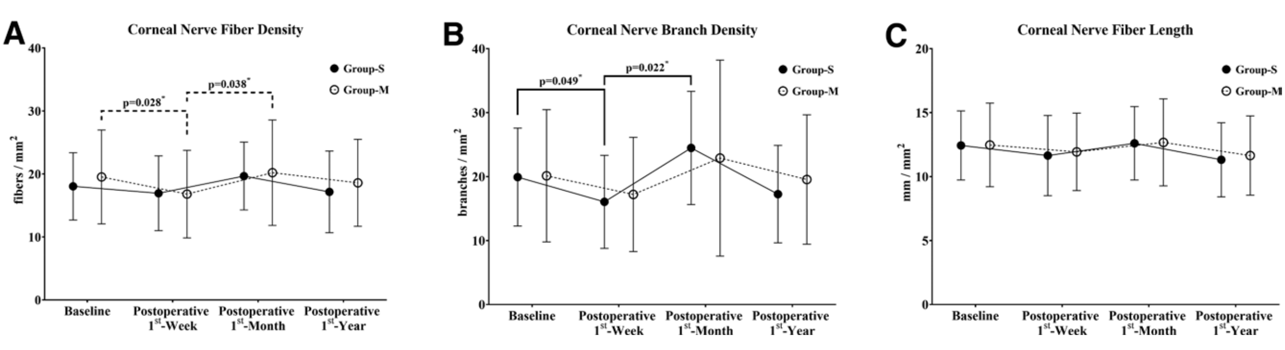

FIG. 2. Subbasal nerve plexus parameters of in vivo corneal confocal microscopy during the Study period in Group-S and Group-M. **A**, Corneal nerve fiber density. **B**, Corneal nerve branch density. **C**, Corneal nerve fiber length. *Statistical significance determined by 1-way repeated measures analysis of variance with Bonferroni correction.

comparable with the baseline during the first month and first year without reaching a statistical significance in both groups (Table 1 and Fig. 2).

There was no corneal fluorescein staining, and no significant change was observed in Schirmer I (mm) test results and NI-TBUT (sec) in any group during any postoperative period (Fig. 3A,B). However, MGAL (%) changed significantly both in Group-S (F[1.47, 33.76] = 9.32, p = 0.002) and Group-M (F[2.45, 56.44] = 5.31, p = 0.005) (Table 1 and Fig. 3C). This significant change resulted from the difference of MGAL in the postoperative first year compared with baseline (p = 0.030) and postoperative first week (p = 0.005) in Group-S and postoperative first year compared with baseline (p = 0.023) as well as to postoperative first week (p = 0.006) in Group-M (Table 1 and Fig. 3C).

Regarding the changes in eyebrow positions, although there was a slight increase in CBH (mm) and LBH (mm) in the postoperative first year in Group-S, this change did not reach statistical significance. However, CBH and LBH were significantly increased in Group-M (F[2.42, 55.56] = 7.89, $p < 0.001$ and F[2.21, 50.74] = 3.80, p = 0.025, respectively) (Table 1). For CBH, the statistical significance resulted from the change in postoperative first month and first year compared with baseline (p = 0.028 and 0.004, respectively), as well as first month compared with first week (p = 0.032), for LBH from first year compared with baseline (p = 0.044) (Table 1 and Fig. 4).

When the mean differences between baseline and postoperative parameters were evaluated between groups, there was only a significant difference in the change of CBH between baseline and postoperative first year in Group-S compared with Group-M (0.08 ± 0.65 and 0.63 ± 0.77 mm, p = 0.011, respectively) (Supplementary Table 1, Supplemental Digital Content 1, available at http://links.lww.com/IOP/A361).

There were no postoperative complications in any group other than edema and bruising, which resolved spontaneously.

DISCUSSION

This first study evaluating the effects of upper eyelid blepharoplasty on the corneal nerves by IVCCM showed that, even if corneal subbasal nerve plexus parameters might be adversely affected in the short term, these effects regress in the long term and do not affect the evaluated DED parameters. Furthermore, those effects were regardless of the inclusion of orbicularis oculi resection in the surgical procedure. However, both surgical methods resulted in mild meibomian gland loss in the long term, indicated by an increase in MGAL. In addition, while the skin-only procedure did not affect the position of the eyebrows, the orbicularis oculi resection during the upper eyelid blepharoplasty could slightly raise the CBH and LBH.

Blepharoplasty is the first and second most commonly performed cosmetic surgery for those over 65 and 50 years of age, respectively.[1] Since the incidence of DED was reported to increase in patients older than 50 years,[24]

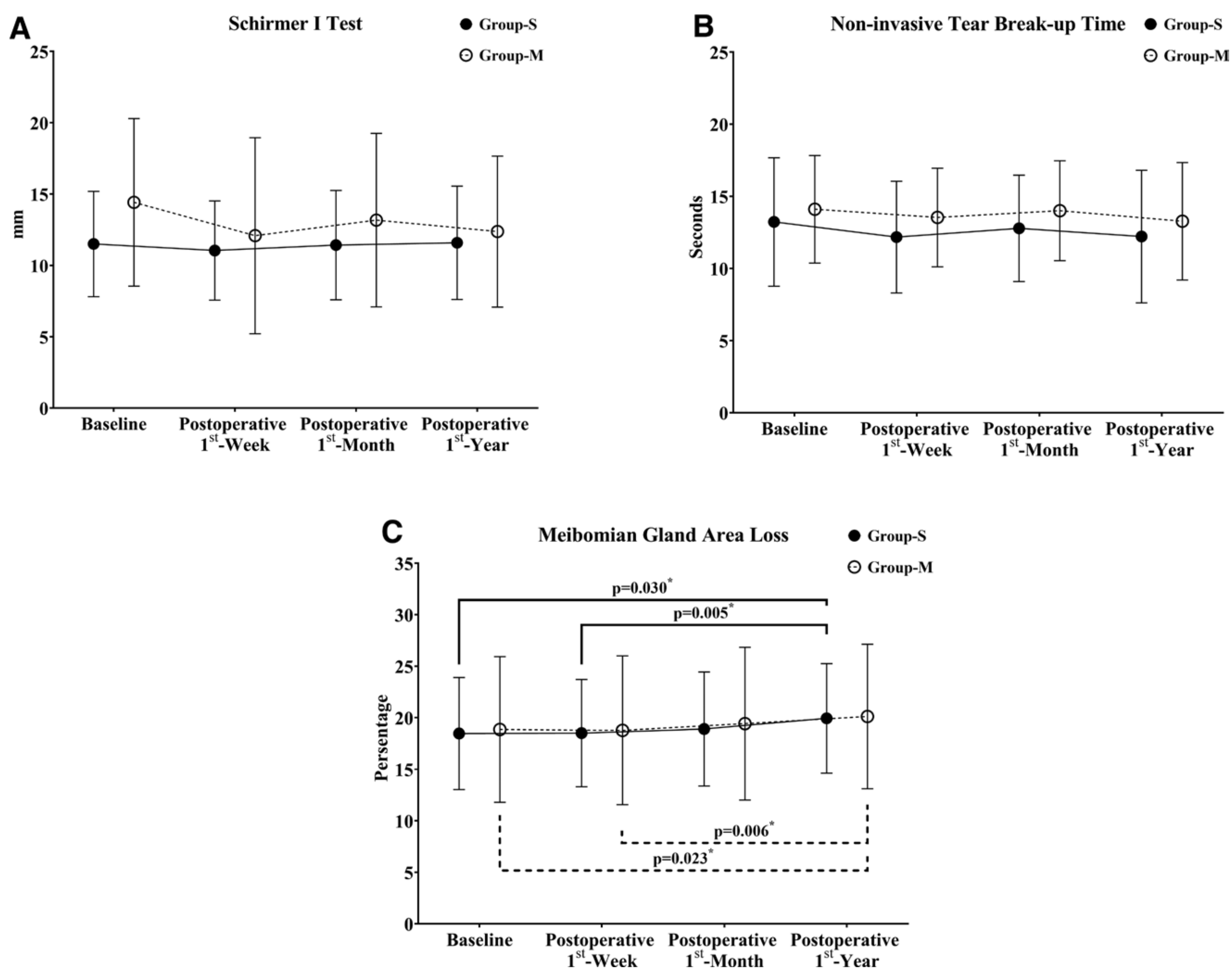

FIG. 3. Schirmer I test results (**A**), noninvasive tear breakup time (**B**), and meibomian gland area loss (**C**) during the study period in Group-S and Group-M. *Statistical significance determined by 1-way repeated measures analysis of variance with Bonferroni correction.

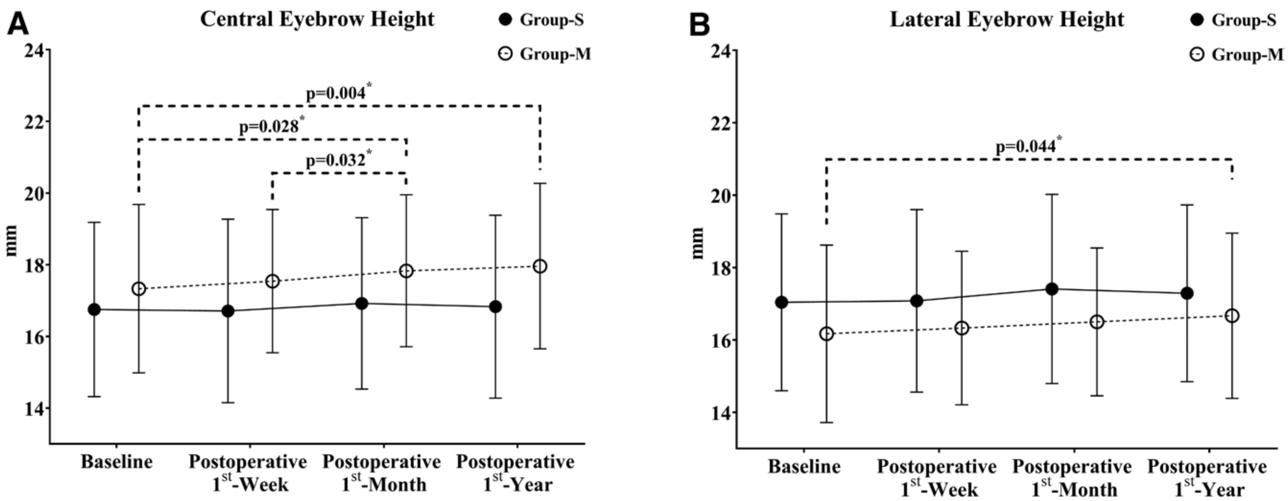

FIG. 4. Eyebrow positions of Group-S and Group-M during the study period. **A**, Central eyebrow height. **B**, Lateral eyebrow height. *Statistical significance determined by 1-way repeated measures analysis of variance with Bonferroni correction.

blepharoplasty-associated DED is an important area of research, particularly in this population. Recently, Hollander et al.[10] evaluated the DED parameters of upper eyelid blepharoplasty patients with or without orbicularis oculi muscle resection with a randomized controlled trial for the first time in the literature. They reported no significant change in the skin-only group; however, the muscle excision group showed an increase in the tear breakup time and tear osmolarity at the postoperative sixth month. Still, the results returned to preoperative levels in the postoperative first year with the improvement of the subjective Ocular Surface Disease Index score in both groups. They concluded that blepharoplasty did not trigger dry eye symptoms in the long term.[10] On the other hand, in their study, Kiang et al.[9] applied skin-only excision in 1 eye and skin-plus-orbicularis oculi excision in the other eye of the patients, and they showed that dry eye symptoms could develop if the muscle excision were 9 mm or more. Unlike the study mentioned above, the excision of the orbicularis oculi muscle between 3 and 5 mm in our study can be why we did not observe any significant changes in evaluated DED parameters.

The corneal subbasal nerve plexus is responsible for the sensation of dryness, temperature, touch, and pain, as well as the blink reflex and tear production.[25] These sensory nerves are superficially present on the corneal surface and are susceptible to environmental factors, trauma, and ocular surface diseases.[19] The Dry Eye WorkShop report stated that the corneal surface epithelial cells could be affected by mechanical trauma related to eye blinking, resulting in damage to corneal nerve branches.[26] Moreover, increased eyelid pressure was found to be associated with DED.[21] Thus, it is worth investigating the effect of upper eyelid blepharoplasty on the corneal nerves, which causes marked periorbital swelling.

The IVCCM finding of this study showed a reduction in the CNBD and CNFD parameters in Group-S and Group-M during first postoperative week, respectively. This reduction in nerve density and branches supports the findings of the previous study, in which a significant decrease in corneal sensitivity was reported in the early postoperative period in patients who underwent upper eyelid blepharoplasty.[27] Moreover, consistent with our results suggesting a regeneration process during the postoperative first month, Kim et al.[27] also found a significant increase in corneal sensation and tear production at the postoperative first month compared with the postoperative first day and baseline, respectively. The increase in subbasal nerve plexus parameters in our study might suggest a reinnervation, possibly due to the rebound secretion of neuropeptides, growth factors, and cytokines after a corneal injury, as demonstrated in the previous study.[28] Although no deterioration or improvement was observed in corneal staining, NI-TBUT, and Schirmer I test, the findings of our study may explain the Ocular Surface Disease Index score and tear production improvement shown in other studies.[12,13,27] However, since Ocular Surface Disease Index scores and tear production were not evaluated in our research, we think this prediction can be considered speculation and need to be investigated in further studies.

Although not exclusively studied, the literature suggests that a decrease in meibomian gland secretion due to insufficient and weak blinking may cause the development of DED after eyelid surgeries.[29] However, in videographic studies evaluating the blink reflex after upper eyelid blepharoplasty, no significant change was observed in the blink reflex despite muscle removal,[15–17] suggesting that the blink reflex alterations are not the mechanism underlying postoperative DED.[16] Furthermore, Wan et al.[30] reported no change in meibum secretion in the postoperative first week of patients with insufficient blink reflex due to facial paralysis, with a decrease over 3 months. However, to our knowledge, no studies evaluate meibomian gland morphology after upper eyelid blepharoplasty. We found a significant reduction in the meibomian gland area expressed as an increase in MGAL in the postoperative first year, compared with baseline evaluation. It has been suggested that ductal and acinar epithelia undergo cell stress due to increased intraglandular pressure in obstructive meibomian gland dysfunction, which triggers mitogen-activated protein kinase activity and ultimately causes the occurrence of inflammation in the meibomian glands.[29] Therefore, we thought that the gland area loss might be caused by inflammation triggered by surgery and insufficient compression of the glands due to muscle removal or desensitization.

Another association suggested in the literature between blepharoplasty and DED is based on decreased meibum secretion and possible related alterations in the tear lipid layer.[14] However, the number of studies questioning the validity of this theory is limited. Recently, 2 studies evaluating NI-TBUT in patients with orbicularis oculi resection showed that NI-TBUT increased in the postoperative first week and returned to baseline values in the postoperative first month.[12,13] In addition, Zhang et al.[13] evaluated changes in the tear lipid profile after blepharoplasty and found that, while the lipid layer thickness increased in the first week, it returned to preoperative values in the first postoperative month. The authors interpreted these findings as they have resulted from increased pressure in the meibomian glands due to the swelling of the lid and the protection of the Riolan muscle around the glands.[13] However, long-term lipid changes in the tear film layer after blepharoplasty remain unknown, as the study only reported short-term results. When evaluated together with our research, investigating how the decrease in the meibomian gland area in the long term affects the tear lipid profile may provide vital information for further studies.

Since blepharoplasty is an operation that can be applied for cosmetic purposes in addition to its therapeutic applications, the effect of blepharoplasty on the position of the eyebrows and eyelids becomes an important issue. The orbicularis oculi muscle consists of 3 parts pretarsal, preseptal, and orbital. Pretarsal and preseptal parts take charge of involuntary blinking and unforced eyelid closure.[31] Therefore, the effect of preseptal orbicularis oculi resection on upper eyelid position was investigated in the literature. While an elevation of marginal reflex distance-1 was reported by some groups of researchers,[32,33] Putthirangsiwong et al.[34] reported that the excision of the preseptal part of orbicularis oculi could increase the risk of postoperative marginal reflex distance-1 decrease. The authors related this decrease to the deeper dissection in the pretarsal region could directly disinsert the levator palpebrae superioris fibers at the tarsal margin. Although the eyelid position was not evaluated in the present study, blepharoptosis was not observed in patients whose pretarsal-preseptal intersection was protected, and the septum was not opened. In addition, in the upper eyelid, the postorbicularis facia of the preseptal orbicularis oculi is continuous with the eyebrow fat pad.[31] Similarly, the orbital portion is continuous with the eyebrow fat pad, and both the preseptal and orbital parts take action in increasingly forceful eyelid closure by centripetal overriding of these 2 components.[31] The preseptal and orbital orbicularis oculi muscles work opposite to the frontalis muscle, which is an elevator of the eyebrow; thus, it has been suggested that the removal of the preseptal orbicularis oculi may increase eyebrow height.[5] In the literature, some studies report that the eyebrow position is lowered[35] or not changed[32,36] after skin-plus-muscle excision blepharoplasty. However, similar to our study, Patrocinio et al.[5] also reported an increase in eyebrow position in patients with orbicularis oculi resection but no change in patients with skin-only removal.[5] The significant increase in eyebrow position found in our study might be related to our technique in which a bulk of the large preseptal orbicularis oculi muscle is excised from the temporal side along with a strip-shaped muscle. Therefore, orbicularis oculi resection with this technique might be preferred in patients with dermatochalasis and droopy eyebrows. However, because eyebrow height also increases with age,[37] some can claim that raising the eyebrows is incompatible with a younger appearance. Therefore, the choice of operation method should be considered individually for each patient.

The study's limitations are that the patients were not randomized, and the operation method was selected according to the surgeon's preference. This limitation potentially could lead to (inadvertent) selection bias and, therefore, favor one group or the other. Although there was no significant difference between the 2 groups in preoperative evaluations, orbicularis oculi resection was recommended for patients with a fuller eyelid appearance. As a result, a more pronounced change in eyebrow height might have occurred, which should be considered when evaluating the results. In addition, another significant limitation of our study stems from the nature of IVCCM, which enables us to evaluate only a small field of corneal area (400 × 400 μm). Although the reproducibility of IVCCM is high with the use of 6 central corneal images to quantify mean subbasal nerve parameters,[38] it is possibly unable to image the same central corneal area in longitudinal analysis, even if the patient is fixed at the same fixation point. This study's strengths are its prospective nature and comparison of 2 surgical methods on DED parameters in early and late postoperative periods. This study provides valuable results in evaluating corneal nerves and meibomian glands to elucidate the mechanism of postoperative blepharoplasty-related DED; however, the exploratory findings of this study need to be supported by further studies.

In conclusion, this study demonstrated that upper eyelid blepharoplasty could be considered within safe limits for corneal subbasal nerves in the early- and long-term postoperative periods, regardless of including muscle resection in the procedure. Regarding the meibomian gland morphology, although no significant change was observed in the early period, mild atrophy can develop in the late period after upper blepharoplasty with both surgical methods. Therefore, ophthalmological assessment and preoperative evaluation of the meibomian glands can be crucial in patients with extensive gland atrophy. Furthermore, a strip of muscle resection, with the additional inclusion of a triangle shape temporal orbicularis oculi muscle removal, can slightly elevate the eyebrow position. Therefore, the surgical technique in blepharoplasty should be chosen individually according to each patient's needs regarding eyebrow position.

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