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Original Article

The Effects of Blepharoptosis Surgery on Meibomian Gland, Tear Film, and Corneal Topography

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Abstract

Objectives: The objective of this study was to evaluate the Meibomian gland (MG), tear film, and corneal changes in the post-operative period following ptosis surgery using corneal topography.

Methods: This non-comparative, case series study analyzed 30 eyes of 23 patients undergoing blepharoptosis surgery with an external approach. Ocular surface and tear film evaluation was performed at baseline and post-operative 3rd month. The corneal topography was used to assess the MG, the noninvasive tear film break-up time (NI-TBUT), K values, astigmatism, and corneal aberrations. For the examination of dry eyes, the I-TBUT, Schirmer, and ocular surface disease index (OSDI) questionnaires were also performed.

Results: The study involved patients with a mean age of 55.1±18.11 years. Postoperatively, marginal reflex distance 1 is significantly increased (1.23±1.09 vs. 3.65±0.65; p=0.001). Results revealed no significant changes in Kmean (43.65±1.15 vs. 43.67±1.14; p=0.727), astigmatism (−1±0.74 vs. −0.99±0.68; p=0.910), and corrected distance visual acuity logMAR (0.09±0.1 vs. 0.07±0.11; p=0.497). There was a significant increase in MG loss area postoperatively (5.02±5.04–7.75±6.75; p=0.047), while the degree of MG loss did not significantly change (0.2±0.48 vs. 0.37±0.56; p=0.132). However, no significant differences were detected in Schirmer I test (17.4±4.7 vs. 16.1±5.5; p=0.711), I-TBUT (12.4±3.1 vs. 11.9±4.7; p=0.483), and OSDI questionnaire score (16.7±9.4 vs. 17.9±10.3; p=0.176) between baseline and post-operative measurements. Similarly, no significant changes were found in NI-TBUT (5.73±3.72 vs. 6.58 4.71; p=0.535) and NIAvg-TBUT (6.06±4.8 vs. 7.51±4.43; p=0.322) values.

Conclusion: Surgical correction of blepharoptosis affects MG morphology without causing dry eye at the 3rd month. Post-operative corneal topography is useful in demonstrating changes in the MG.

Keywords: Dry eye, Meibomian glands, ptosis, topography

Introduction

Ptosis is a disorder of the eyelid in which the upper eyelid is positioned abnormally low. The most commonly used technique for correction involves advancing the levator externally, provided the levator is functioning (1,2). Since the cornea is in direct contact with the eyelids, changes in eyelid shape and function can lead to alterations in corneal surface and biomechanics. Several parameters, including corneal spherical and cylindrical power, corneal aberrations, and contrast sensitivity, have been observed to vary significantly as a result of ptosis correction several months after surgery (3,4).

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Dry eye symptoms, an important post-eyelid surgery observation, may also worsen after blepharoptosis surgery due to various factors, including post-operative inflammation, chemosis, lagophthalmos, excessive orbicular denervation and resection, lid retraction, and dysfunction of the lacrimal pump system. It is known that these symptoms may be transient in the first few weeks and will likely resolve within 2–3 months after surgery (5,6). However, it should be noted that gland orifice migration or subclinical gland inflammation could also contribute to this pathophysiology (7). On the other hand, there is insufficient published data regarding the impact of aponeurotic blepharoptosis surgery on the Meibomian gland (MG).

This study aims to evaluate the characteristics of MG, tear film, and corneal changes in the 3rd post-operative month following ptosis surgery, utilizing corneal topography.

Methods

This is a non-comparative, cross-sectional case series study involving patients who underwent blepharoptosis surgery at Şişli Hamidiye Etfal Training and Research Hospital between January 2022 and January 2023. The study was conducted in accordance with the tenets of the Declaration of Helsinki and received approval from the local institutional review board. Written informed consent was obtained from all patients who participated in the study.

Study Population

This study was conducted on 30 eyes (17 right, 56.67%; and 13 left, 43.33%) from 23 consecutive patients affected by congenital and acquired ptosis. The congenital ptosis group consisted of 4 eyes from 4 males, while the acquired ptosis group consisted of 25 eyes from 8 males and 11 females. The inclusion criteria were as follows: Age >18 years, margin reflex distance 1 (MRD1) more than 2 mm lower than the normal side or patients with a distance of more than 2 mm between the upper limbus and the upper eyelid margin, and levator function of more than 12 mm. Patients with previous eyelid surgery, rigid gas-permeable contact lens wear, severe dry eye, Sjögren's syndrome, blepharospasm, cranial nerve palsies, Myasthenia gravis, Steven Johnson syndrome, strabismus, and previous ocular trauma were excluded from the study.

A comprehensive eye examination was performed in each patient preoperatively and at the 3rd month postoperatively. This examination included automatic keratometry, visual acuity measurement using a Snellen chart, eye motility testing, slit lamp biomicroscopy, intraocular pressure measurement, and dilated fundus examination. Measurements of MRD and levator muscle function were also recorded. Dry eye was assessed using conventional tear film measurements, including the Schirmer 1 test, invasive (1% fluorescent dye) tear-film breakup time (I-TBUT), and the ocular surface disease index (OSDI) questionnaire.

Corneal Topography

Corneal topography and aberrometry were conducted using the Scheimpflug camera system Sirius (Phoenix software v2.1, Costruzione Strumenti Oftalmici, Florence, Italy), both before the surgery and 3 months postoperatively. Three precisely focused, centered, and aligned images were captured for each eye. Patients were instructed to blink before each image capture to minimize the impact of corneal surface dryness. Topographic analyses provided mean keratometry (Kmean) values, maximum keratometry (Kmax), corneal astigmatism and its axis, central corneal thickness (CCT), and anterior chamber depth (ACD) values. The Symmetry Index front (SIf), which evaluates vertical asymmetry, was also recorded; positive values indicate that the lower hemisphere is steeper than the upper hemisphere, while negative values indicate the opposite (8).

Anterior corneal higher-order aberrations (HOA) were observed within the central 4.0 mm zone. Pupil diameters were measured under different light conditions in a dark room, following scotopic (with an LED source of 0.4 lux), mesopic (with ambient light intensity at 4.0 lux), and photopic (with ambient light intensity at 40 lux) conditions as recommended by the manufacturer (9).

Initially, non-I-TBUT (NI-TBUT) was evaluated during the measurement process. The device identified the first break visible in the Placido ring as the NI-TBUT, while the average NI-TBUT was calculated as the mean duration of all corneal break-ups following blinking.

For Meibography, the tarsal conjunctival surface was photographed 3 times with the upper eyelids everted. Images of MG structures with the highest quality were selected. The infrared illumination of the everted eyelid revealed MGs as hyperlucent vertical clusters. A trapezoidal marker was applied to the tarsal conjunctival surface, encompassing the MG region to indicate the eyelid margins. MGs that were not visible on the meibography were labeled as "MG loss." The device software automatically calculated the loss rates for MGs in designated areas as a percentage and the disease score in degrees: Degree 0 corresponds to a 0–10% loss of MGs, Degree 1 to a 25–50% loss, Degree 2 to a 50–75% loss, and Degree 4 to a 75–100% loss (8,9).

Surgery Technique

The surgery was conducted by senior oculoplastic surgeons using the same method. In brief, under local anesthesia, the skin was excised, and the anterior surface of the tarsus was reached through the removal of the orbicularis oculi muscle and pretarsal tissue. The levator aponeurosis was dissected from the Müller muscle, elevated like a flap, advanced, and then sutured in a position 2–3 mm caudal to the upper edge of the tarsus. To achieve a natural curvature, the levator aponeurosis was attached to the tarsus at two or three different points using 6–0 polypropylene sutures. This was followed by the placement of eyelid crease reforming sutures and closure of the skin. The dressing patch was removed after 1 day, and the skin sutures were removed 1 week after surgery. Topical combined antibiotic-steroid eye drops (Moxidexa, Abdi Ibrahim, Türkiye) and artificial tears (Eyestil Unidose, SIFI, Italy) were applied 4 times a day, along with antibiotic ointment (Thiocilline, Abdi İbrahim, Türkiye) applied 3 times a day, all of which were continued for 10 days.

Statistical Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS version 21.0; IBM Corp., Armonk, N.Y., USA). A statistical significance level of $P < 0.05$ was chosen. Descriptive statistics were provided in terms of mean and standard deviation (SD) for numerical variables, and frequency and percentage analysis for categorical variables. The distribution of the pre-operative and post-operative 3rd month variables was assessed for normality using the Shapiro–Wilk test, revealing that they were not normally distributed ($p<0.05$). The Wilcoxon test was employed to compare the variables obtained preoperatively and at the third post-operative month. Relationships between numerical variables were analyzed using Spearman correlation analysis.

Results

The mean±SD age was 55.1±18.11 (18–81). There was no early recurrence, which needed revision surgery. MRD 1 showed a significant increase postoperatively (1.23±1.09 vs. 3.65±0.65; p=0.001). The mean change of MRD2 was not statistically significant (5.3±0.42 vs. 5.18±0.4; p=0,157). No significant differences were observed between pre-operative and post-operative 3-month results for Kmean (43.65±1.15 vs. 43.67±1.14; p=0.727), astigmatism (−1±0.74 vs. −0.99±0.68; p=0.910), and corrected distance visual acuity (CDVA) logMAR (0.09±0.1 vs. 0.07±0.11; p=0.497). Corneal aberrations and pupillographic measurements also showed no significant changes from the pre-operative values. Detailed pre-operative characteristics were compared to post-operative results as shown in Table 1.

A notable increase was observed in the area of MG loss postoperatively (5.02±5.04 vs. 7.75±6.75; p=0.047), but no change was noted in MG loss degree (0.2±0.48 vs. 0.37±0.56; p=0.132). Changes in MG loss degree were given in Figure 1. However, no significant differences were detected between baseline and 3-month post-operative values for Schirmer 1 test (17.4±4.7 vs. 16.1±5.5; p=0.711), I-TBUT (12.4±3.1 vs. 11.9±4.7; p=0.483), and The OSDI questionnaire score (16.7±9.4 vs. 17.9±10.3; p=0.176). Similarly, there were no significant changes in NI-TBUT (5.73±3.72 vs. 6.58±4.71; p=0.535) and NI-avgBUT (6.06±4.8 vs. 7.51±4.43; p=0.322) values.

A significant, positive, and moderate correlation was observed between the area of MG loss and the MG disease score (r=0.697, p=0.001). The correlation analysis indicated no statistically significant changes between area of MG loss and other parameters (p>0.05).

Discussion

The results of this study reveal that the amount of MG loss area after blepharoptosis surgery does not lead to clinical dry eye in the 3rd post-operative month. Furthermore, no significant changes in visual acuity, Kmean, Kmax, corneal astigmatism and axis, SIf, corneal HOA, and corneal astigmatism were observed.

The stability of the tear film is maintained by the eyelid, which also serves to protect the ocular surface. In addition, factors such as blinking and tear osmolarity that affect tear stability are important in the pathogenesis of dry eye disease (10,11). The secretion of MG affects tear osmolarity, and an increase in tear osmolarity is observed in cases of MG dysfunction (12,13). Intervention in the levator muscle and changes in eyelid position in blepharoptosis surgery can influence blinking function, while manipulations performed on the tarsal plate can affect MGs.

In a study by Gülal and Eroğul in which MGs were evaluated by topographic measurement method in the first and 3rd months after various eyelid procedures, it was reported that there was a significant increase in post-operative MG loss in cases with ptosis repair (7). Shirakawa et al. in their study in which they examined MG morphology, tear meniscus height (TMH), I-TBUT, and Schirmer test between pre-operative and post-operative 6 months in levator surgery reported that tarsal sutures applied during ptosis surgery did not cause a statistically significant loss in MGs in the post-operative period. In addition, they did not find a statistically significant difference in TMH, I-TBUT, and Schirmer test. They also reported that it may be difficult to evert the eyelid in some cases after this surgery (14).

Similarly, in our study, we observed a statistically significant increase in the MG area of loss postoperatively. We think that tarsal sutures and other manipulations on the tarsus may affect the MGs through direct trauma or by triggering inflammation. However, this difference was not significant for the MG disease score. This may be due to the fact that the evaluation of the disease score is made by considering a certain range. Moreover, in our study, the change in MG loss was not large enough to affect the disease score. We think that studies covering the early and late post-operative periods may enlighten when exactly MG loss begins and resolves.

Table 1. Pre-operative and post-operative visual, clinical, and topographic parameters of the study patients

Variables	Pre-operative		Post-operative		Change	p
	Mean±SD	Median (Q1–Q3)	Mean±SD	Median (Q1–Q3)		
CDVA, logMAR	0.09±0.1	0.05 (0–0.15)	0.07±0.11	0 (0–0.1)	-0.01±0.09	0.497
MRD 1.mm	1.23±1.09	1 (1–2)	3.65±0.65	4 (3–4)	2.42±0.82	0.001*
MRD 2.mm	5.3±0.42	5 (5–5.5)	5.18±0.4	5 (5–5)	-0.14±0.24	0.157
Kmean, D	43.65±1.15	43.41 (42.94–44.05)	43.67±1.14	43.55 (43–44.2)	0.02±0.59	0.727
Kmax, D	46.47±2.79	45.46 (44.69–46.84)	44.67±8.74	45.21 (44.61–48)	-1.82±9.51	0.412
Astigmatism.D	-1±0.74	-0.8 (-1.14–-0.61)	-0.99±0.68	-0.88 (-1.08–-0.6)	0.02±0.49	0.910
Axis	88.6±60.14	93 (26–142)	78.87±56.05	83 (19–111)	-9.73 ±48.45	0.673
SIf	-0.12±0.81	0.08 (-0.6–0.42)	-0.22±0.75	-0.11 (-0.9–0.35)	-0.09±0.61	0.545
Central corneal thickness, µm	553±30.4	554 (543.2–566.1)	553.3±30.4	549 (542.9–565.2)	0.6±12.1	0.964
ACD, mm	2.88±0.43	2.79 (2.44–3.27)	2.89±0.44	2.79 (2.55–3.33)	0.02±0.1	0.258
Scotopic pupil.mm	4.59±1.33	4.38 (3.33–5.56)	4.48±1.27	4.73 (3.21–5.58)	0.05±0.84	0.943
Mesopic pupil.mm	3.86±1.06	3.52 (3.08–4.72)	3.97±1.18	3.77 (3.02–4.65)	0.12±1.11	1.000
Photopic pupil.mm	3.37±0.91	3 (2.7–3.72)	3.41±1.08	3.2 (2.75-3.77)	0±0.96	0.354
HOA, µm	0.28±0.13	0.25 (0.16–0.4)	0.26±0.11	0.26 (0.19–0.32)	-0.01±0.12	0.776
Coma, µm	0.11±0.08	0.09 (0.06–0.13)	0.12±0.06	0.12 (0.06–0.17)	0.01±0.07	0.611
Trefoil, µm	0.16±0.11	0.12 (0.07–0.26)	0.16±0.1	0.13 (0.08–0.21)	0.01±0.11	0.820
Spherical aberration, µm	-0.2±0.91	-0.02 (-0.07–0.01)	-0.03±0.04	-0.02 (-0.05–-0.01)	0.18±0.91	0.458
MG area of loss, %	5.02±5.04	3.5 (2–7)	7.75±6.75;	7.4 (2.2–13)	2.64±6.63	0.047*
MG degree	0.2±0.48	0 (0–0)	0.37±0.56	0 (0–1)	0.17±0.59	0.132
NI-TBUT	5.73±3.72	4.3 (3.2–7.6)	6.58±4.71	5.1 (2.7–9.2)	1.2±6.94	0.535
NIAvg-TBUT	6.06±4.8	5.1 (2.5–10.4)	7.51±4.43	6.8 (3.75–10.45)	1.69±7.04	0.322
Schirmer I test, mm	17.4±4.7	15.7 (13.2-18.7)	16.1±5.5	15.1 (11.7-18.2)	-1.21±6.5	0.711
I-TBUT	12.4±3.1	11.6 (9.4-13.9)	11.9±4.7	11.1 (8.9-14.2)	-0.7±2.6	0.483
OSDI	16.7±9.4	13.5 (8.3-17.1)	17.9±10.3	14.4 (9.8-17.9)	1.1±5.2	0.176

Change: Mean difference between postoperative and pre-operative values, SD: Standard deviation, Q: quartile, CDVA: corrected distance visual acuity, MRD: Margin reflex distance, K: Keratometry, SIf: Symmetry index front, Axis: Axis of cylindrical value, HOA: Higher order aberration, ACD: Anterior chamber depth, MG: Meibomian gland, NI-TBUT: Noninvasive first tear film break-up time, NIAvg-TBUT: Noninvasive average tear film break-up time, I-TBUT: Invasive tear-film breakup time, OSDI: Ocular surface disease index, *Wilcoxon test.

Kim et al. in their study where they evaluated corneal sensitivity and Schirmer's test before and after blepharoplasty and blepharoptosis surgery, they reported that corneal sensitivity, which they found decreased on the 1st day, showed a statistically significant increase in the 1st month, and that the Schirmer test also increased in the 1st month (15). In contrast, Watanabe et al. in their study, observed that the post-operative tear volume decreased significantly, especially in cases with high tear volume at the beginning, after blepharoptosis surgery for at least 6 months (16).

In our study, despite the significant loss of MGs in the post-operative 3rd month, the stability of NI-TBUT and NIAVG-TBUT values, which allows the evaluation of tear film stability, can be explained by compensatory tear fluid secretion increase due to MG dysfunction. The lack of significant increase might be attributed to the potential adverse effect of increased evaporation due to the heightened lid aperture.

In their study, Aksu Ceylan and Yeniad investigated the effects of upper eyelid blepharoplasty and blepharoptosis surgery on the ocular surface at 1 day, 1 week, 1 month, 3 months, and 6 months postoperatively. They reported that the decrease in I-TBUT value at 1 week in the group that only underwent ptosis surgery returned to normal in the 1st month. However, they observed that the decrease in Schirmer's test continued at 6 months in the group in which

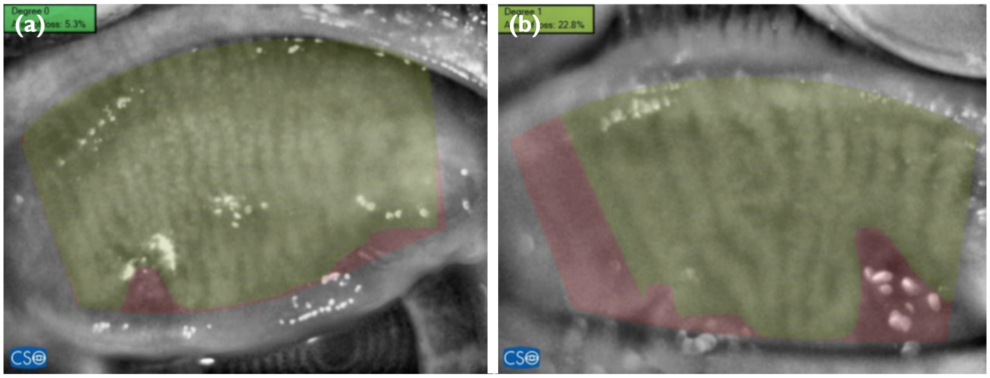

Figure 1. Pre-operative **(a)** and post-operative **(b)** Meibomian gland area of loss.

blepharoplasty was performed alone or in combination with ptosis surgery (17). Their study supports the hypothesis regarding the role of the orbicularis muscle in the development of dry eye.

In another study conducted on patients with symptomatic scores and TBUT values indicating dry eye disease before involutional ptosis surgery, improvement was found in symptom scores and TBUT values at 6 months postoperatively (18). It could be suggested that the initial dry eye symptom status might influence changes in postoperative dry eye scores, a notion supported by the results of our study. In our study, there was no significant deterioration in postoperative I-TBUT and Schirmer I tests, while a nonsignificant improvement in NI-TBUT measurements and a nonsignificant increase in OSDI scores were observed. However, both pre-operative and postoperative OSDI scores were consistent with mild dry eye disease. Although OSDI scores are sufficient to classify dry eye disease, it is known that they do not correlate well with clinical dry eye tests (19).

Many other studies after blepharoptosis surgery have also reported the effects of this surgery on refractive corneal topographic measurements (6,17,22-28). In addition, before making any further decisions, it is advised to wait 3 months after blepharoplasty surgery to repeat corneal topography and refraction because post-operative eyelid edema can persist for up to 2 months after the procedure (6,20).

Studies have reported that the pressure exerted by the eyelid steepening the cornea's central region while flattening its periphery. Therefore, eyelid lifting is expected to cause central flattening and peripheral steepening (17,21). Brown et al. noted approximately 0.60 D and 0.55 D in average dioptric alterations by following ptosis correction and blepharoplasty procedures, respectively. According to Brown et al., between 1 and 3 months following surgery, the number of patients with increased astigmatism was roughly the same as the number of patients with decreased astigmatism (22). In their study, Zinkernagel et al. observed a total corneal astigmatic change of 0.19 D in the blepharoplasty and fat pad reduction groups and 0.25 D in the levator surgery and ptosis repair groups in the 3rd postoperative month, but they were unable to find a statistically significant change in the astigmatic axis. The authors' experience has shown that astigmatic changes of 0.2 D or more can influence visual acuity and may be observed by the patient (23). In their study of corneal topography changes following ptosis surgery, Savino et al. discovered a change in mean keratometry values of 0.15 D, an increase in astigmatism of 0.26 D, and a change in mean axis values of 10° (24).

In our study, there was no significant change in CDVA, Kmean, CCT, ACD, and astigmatism axis although a decrease was observed in Kmax and astigmatism values; this difference was not statistically significant. In addition, a decrease was observed in the SIf value, which evaluates the vertical asymmetry. This shows that the steepening effect seen in ptosis in the upper hemisphere of the cornea compared to the lower hemisphere continues in the postoperative period. However, these findings not being significant may also be related to the small sample size. In addition, some studies reported that additional factors such as higher astigmatism in the pre-operative period, severity of ptosis level, and deep superior sulcus were associated with higher corneal astigmatism changes in the postoperative period (6).

Contrast sensitivity is significantly influenced by HOA, which is the distortion that results from a wavefront of light interacting with an eye that has a refractive component. Lower-order aberration and HOA increase as participants narrow their palpebral fissures (25). Therefore, blepharoptosis surgery that changes the lid aperture may affect aberration and contrast sensitivity. Sharifi et al. evaluated topography and aberrations of ptosis preoperatively and 3rd months postoperatively after anterior levator resection. They reported that the change in total HOAs was not statistically significant. However, a reduction in the amount of third-order deviations (vertical coma and vertical trefoil) was statistically significant for vertical coma. They suggested that as a result, surgical correction of ptosis could reduce aberrations even though there was no significant change in astigmatism, and that non-axial HOAs were mostly affected, possibly due to the meridional effect of ptosis on the cornea (26). Han et al. in their study found pre-operative third-order and coma-like aberrations significantly more common in the ptosis repair group than in the blepharoplasty group; both decreased significantly after the operation (27). According to a study by Altin Ekin and Karadeniz Ugurlu HOA at 6 mm pupil size significantly improved 1 month after blepharoplasty. Patients having a pre-operative MRD1 of <2 mm showed a greater improvement (28).

Although a decrease in HOA value was observed in our study with a pupil size of 4 mm, this difference was not statistically significant. We also did not find a statistically significant difference in coma, trefoil, and spherical aberration values. Since aberrations were examined over different pupil size values, it was not possible to make a direct comparison but it was interpreted in accordance with other studies. In addition, we did not observe a statistically significant difference between the pupil diameters in different lighting conditions in the pre- and postoperative period.

The limitations of our study are the relatively small sample size and limited follow-up period, lack of a control group, and inability to answer exactly when gland dysfunction begins or whether it is transient or not. A larger series of studies with longer post-operative follow-ups will contribute more to the literature to evaluate whether the findings are temporary or not. However, to the best of our knowledge, this is one of the studies limited in the literature to examine the effect of levator surgery on the upper eyelid MG.

Conclusion

Ptosis surgery induces significant changes in the MG and tear film, as well as its effect on astigmatism and aberrations. Therefore, it may be a better approach to perform levator surgery before when planning intraocular procedures such as cataract and refractive surgery.

Disclosures

Ethics Committee Approval: This study was approved by Şişli Hamidiye Etfal Training and Research Hospital Ethics Committee (Date: 04/07/2023, Number: 2375).

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

Authorship Contributions: Concept – E.C.Y., A.B.D.; Design – E.C.Y., E.B.A.O., A.B.D.; Supervision – E.C.Y., S.T.D.; Resource – E.C.Y., E.B.A.O., A.B.D., I.C.T.; Materials – E.C.Y., A.B.D., I.C.T.; Data collection and/or processing – E.C.Y., E.B.A.O., T.D.; Analysis and/or interpretation – E.C.Y., T.D., S.T.D.; Literature search – E.C.Y., E.B.A.O., T.D.; Writing – E.C.Y.; Critical review – E.C.Y., A.B.D., I.C.T., S.T.D.

References

1. Carraway JH, Tran P. Blepharoplasty with ptosis repair. Aesthet Surg J 2009;29:54–61. [CrossRef]
2. Avdagic E, Phelps PO. Eyelid ptosis (Blepharoptosis) for the primary care practitioner. Dis Mon 2020;66:101040. [CrossRef]
3. Fagien S. Reducing the incidence of dry eye symptoms after blepharoplasty. Aesthet Surg J 2004;24:464–8. [CrossRef]
4. Simsek IB, Yilmaz B, Yildiz S, Artunay O. Effect of upper eyelid blepharoplasty on vision and corneal tomographic changes measured by pentacam. Orbit 2015;34:263–7. [CrossRef]
5. Saadat D, Dresner SC. Safety of blepharoplasty in patients with preoperative dry eyes. Arch Facial Plast Surg 2004;6:101–4.
6. Heidari M, Haydar AA, Rajabi MT, Rafizadeh SM. Corneal biophysical changes after upper eyelid blepharoplasty and ptosis surgery: A review. BMC Ophthalmol 2023;23:253. [CrossRef]
7. Gülal M, Eroğul Ö. Evaluation of the effect of eyelid disorder surgeries on tears and anterior segment parameters with meibography and corneal topography. J Surg Med 2022;6:912–7.
8. Doctor K, Vunnava KP, Shroff R, Kaweri L, Lalgudi VG, Gupta K, et al. Simplifying and understanding various topographic indices for keratoconus using Scheimpflug based topographers. Indian J Ophthalmol 2020;68:2732–43. [CrossRef]
9. Prakash G, Srivastava D, Suhail M, Bacero R. Assessment of bilateral pupillary centroid characteristics at varying illuminations and post-photopic flash response using an automated pupillometer. Clin Exp Optom 2016;99:535–43. [CrossRef]
10. Wang MT, Tien L, Han A, Lee JM, Kim D, Markoulli M, et al. Impact of blinking on ocular surface and tear film parameters. Ocul Surf 2018;16:424–9. [CrossRef]
11. Liu H, Begley C, Chen M, Bradley A, Bonanno J, McNamara NA, et al. A link between tear instability and hyperosmolarity in dry eye. Invest Ophthalmol Vis Sci 2009;50:3671–9. [CrossRef]
12. Arita R, Morishige N, Koh S, Shirakawa R, Kawashima M, Sakimoto T, et al. Increased tear fluid production as a compensatory response to meibomian gland loss: A multicenter cross-sectional study. Ophthalmology 2015;122:925–33. [CrossRef]
13. Messmer EM, Drillisch J, Kampik A. Osmolarity in patients with Meibomian gland dysfunction (MGD). Invest Ophthalmol Vis Sci 2012;53:556.
14. Shirakawa R, Toyono T, Akiyama R, Noda M, Arita R, Yoshida J, et al. Impact of aponeurotic blepharoptosis surgery to the tarsal plate and the Meibomian gland. Invest Ophthalmol Vis Sci 2018;59:4928–8.
15. Kim HH, De Paiva CS, Yen MT. Effects of upper eyelid blepharoplasty on ocular surface sensation and tear production. Can J Ophthalmol 2007;42:739–42. [CrossRef]
16. Watanabe A, Selva D, Kakizaki H, Oka Y, Yokoi N, Wakimasu K, et al. Long-term tear volume changes after blepharoptosis surgery and blepharoplasty. Invest Ophthalmol Vis Sci 2014;56:54–8. [CrossRef]

17. Aksu Ceylan N, Yeniad B. Effects of upper eyelid surgery on the ocular surface and corneal topography. Turk J Ophthalmol 2022;52:50–6. [CrossRef]
18. Asamura S, Wada Y, Tanaka S, Saika S. Study to the effect of involutional blepharoptosis surgery using objective and subjective parameters. Arch Plast Surg 2022;49:473–8. [CrossRef]
19. Grubbs JR Jr., Tolleson-Rinehart S, Huynh K, Davis RM. A review of quality of life measures in dry eye questionnaires. Cornea 2014;33:215–8. [CrossRef]
20. Holck DE, Dutton JJ, Wehrly SR. Changes in astigmatism after ptosis surgery measured by corneal topography. Ophthalmic Plast Reconstr Surg 1998;14:151–8. [CrossRef]
21. Gandhi A, Mehta A, Naik M. Does frontalis sling surgery for congenital ptosis change the corneal topography and refractive characteristics postoperatively? Clin Ophthalmol 2020;14:3667–73. [CrossRef]
22. Brown MS, Siegel IM, Lisman RD. Prospective analysis of changes in corneal topography after upper eyelid surgery. Ophthalmic Plast Reconstr Surg 1999;15:378–83. [CrossRef]
23. Zinkernagel MS, Ebneter A, Ammann-Rauch D. Effect of upper eyelid surgery on corneal topography. Arch Ophthalmol 2007;125:1610–2. [CrossRef]
24. Savino G, Battendieri R, Riso M, Traina S, Poscia A, D'Amico G, et al. Corneal topographic changes after eyelid ptosis surgery. Cornea 2016;35:501–5. [CrossRef]
25. Han W, Kwan W, Wang J, Yip SP, Yap M. Influence of eyelid position on wavefront aberrations. Ophthalmic Physiol Opt 2007;27:66–75. [CrossRef]
26. Sharifi M, Es'haghi A, Kiarudi MY. The effect of ptosis surgery on corneal topography and aberrometry. Saudi J Ophthalmol, Jul 24, 2023. doi: 10.4103/sjopt.sjopt_220_22. [Ahead of Print].
27. Han DJ, Lee DH, Seo JW, Yum JH, Lee JH. Changes in corneal higher-order aberrations and astigmatism after upper eyelid surgery. J Korean Ophthalmol Soc 2022;63:814–22. [CrossRef]
28. Altin Ekin M, Karadeniz Ugurlu S. Prospective analysis of visual function changes in patients with dermatochalasis after upper eyelid blepharoplasty. Eur J Ophthalmol 2020;30:978–84. [CrossRef]