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ORIGINAL RESEARCH

Analysis of Corneal Topography and Wavefront Aberrations after Upper Eyelid Blepharoplasty

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ABSTRACT

In this prospective, interventional study, the effect of upper eyelid blepharoplasty (UEB) surgery performed on dermatochalasis patients on the cornea was investigated by corneal topography, and its effect on visual function was investigated by examining visual acuity and corneal wavefront aberrations. Eighty eyelids of 40 patients were evaluated at least 1 month after surgery. No significant differences were found for visual acuity, flat keratometry, steep keratometry, average keratometry, topographic astigmatism, axis, central corneal thickness, and anterior chamber depth ($p>0.05$ for all). While preoperative anterior chamber volume (ACV) was 122.06±28.0 mm^3, the postoperative ACV was 126.23±28.80 mm^3 ($p=0.045$). Root mean square-higher-order aberrations for total corneal surface (RMS-HOAs) in a 6-mm optical zone decreased significantly from 0.331±0.115 µm to 0.255±0.106 µm ($p<0.001$). The RMS-coma (Z_3^1) ($p=0.841$), RMS-trefoil (Z_3^3) ($p=0.866$), and RMS-quadrifoil (Z_4^4) ($p=0.932$) values were similar. The RMS-spherical aberration (Z_4^0) decreased significantly (0.398±0.301, 0.371±0.280, $p=0.035$). In conclusion, it was seen that UKB surgery can improve the topographic and aberrometric measurements of the cornea in the early postoperative period.

Keywords: Upper eyelid blepharoplasty. Dermatochalasis. Corneal topography. Wavefront aberrations. Higher order aberrations.

Üst Göz Kapağı Blefaroplasti Ameliyatı Sonrası Kornea Topografisi ve Korneal Wavefront Aberasyonların İncelenmesi

ÖZET

Bu prospektif, girişimsel çalışma ile dermatoşalazis hastalarına uygulanan üst göz kapağı blefaroplasti (ÜKB) ameliyatının kornea üzerine etkisi korneal topografi ile, görme fonksiyonuna etkisi ise görme keskinliği ve korneal wavefront aberasyonlar incelenerek araştırıldı. Kırk hastanın 80 göz kapağı ameliyattan en az 1 ay sonra değerlendirildi. Ameliyat öncesi ve sonrası görme keskinliği, düz keratometri, dik keratometri, ortalama keratometri, topografik astigmatizma, aks, santral kornea kalınlığı ve ön kamara derinliği değerleri açısından anlamlı fark yoktu (hepsi için p >0,05) Ameliyat öncesi ön kamara hacmi (ACV) 122,06±28,0 mm3 iken, ameliyat sonrası ACV 126,23±28,80 mm3 (p=0,045) idi. 6 mm'lik optik zonda, total korneal yüzey için root mean square-higher-order aberrations (RMS-HOAs) 0,331±0,115 µm'den, 0,255±0,106 µm'ye düştü ($p<0,001$). RMS-koma (Z_3^1) ($p=0,841$), RMS-trefoil (Z_3^3) ($p=0,866$) ve RMS-quadrifoil (Z_4^4) ($p=0,932$) değerleri benzerdi. RMS- spherical aberration (Z_4^0) istatistiksel olarak anlamlı azaldı (0,398±0,301, 0,371±0,280, $p=0,035$). Sonuç olarak, ÜKB ameliyatı sonrası erken dönemde, korneal topografik ve aberometrik ölçümlerde değişiklikler gözlemlenmiştir.

Anahtar Kelimeler: Üst göz kapağı blefaroplasti ameliyatı. Dermatoşalazis. Kornea topografisi. Wavefront aberasyonları. Yüksek sıralı aberasyonlar.

Dermatochalasis is a cosmetic problem that occurs with age. In addition to causing cosmetic problems, it can cause visual dysfunction and eyelash ptosis due to excessive skin sagging[1]. Upper eyelid blepharoplasty (UEB) is a procedure for treating functional and cosmetic problems. The most typical indication for UEB is upper eyelid dermatochalasis[2]. The general incidence of dermatochalasis is reported to be 16% in individuals over the age of 45, and it is more common in men[3]. It is typically a bilateral condition that causes both visual disturbance and cosmetic problems.

Studies in the literature investigated the effect of UEB on visual function. Meyer et al. reported that statistically significant increases in contrast sensitivity were observed in 28 eyelids of 14 patients postoperatively[4]. Dermatochalasis narrows the visual field both by mechanically blocking it due to excess eyelid tissue and by entering the field of vision due to the deviation of the eyelashes. One study evaluated the visual fields of 17 patients who underwent UEB and documented a 26.2% improvement in the upper visual

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field[5]. Another study measured the contrast sensitivity and higher order aberrations (HOAs) in 22 eyelids of 16 patients with dermatochalasis and there were improvements in contrast sensitivity after UEB due to the changes in the HOAs[6]. Removing excess upper eyelid skin and reducing fat after UEB can cause significant corneal shape changes; it can be associated with topographic corneal changes[6]. Simsek et al. found significant astigmatic changes in patients with dermatochalasis undergoing UEB surgery[7]. Atalay et al. reported that severe dermatochalasis was associated with altered corneal hysteresis measured by the ocular response analyzer[8].

In recent years, an increasing aging patient load has occurred for UEB, increasing our postoperative surgical experience and research. However, very few studies in the literature have examined the effect of UEB, especially on HOAs. Wavefront aberrations, known to affect visual symptoms significantly, can be measured using current optical technologies. Aberrations of the third-order and above are defined as root mean square-high-order aberrations (RMS-HOA), affecting the quality of vision[9,10].

In this study, we aimed to investigate the anatomical (corneal topography) and functional (visual acuity and high-order aberration) outcomes of UEB surgery performed on patients with dermatochalasis.

Material and Method

This prospective, interventional study evaluated 80 eyelids of 40 patients who underwent UEB for dermatochalasis at a single center between June 2023 and June 2024. The hospital's local ethics committee approved the study (number: 2011-KAEK-25 2023/05-14). The study adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from each patient before surgery.

Patients with gross eyelid pathologies other than dermatochalasis, such as ptosis, entropion, ectropion, pterygium, glaucoma, severe dry eye, history of refractive surgery, retinal disease (e.g., age-related macular degeneration, retinal vascular occlusion, diabetic retinopathy), or neuro-ophthalmological disease, were excluded.

First, a detailed history and routine ophthalmologic examination were performed. The best corrected visual acuity (BCVA) was recorded with Snellen's chart and converted to the logarithm of the minimal angle of resolution (logMAR). Schirmer I test, one of the dry eye tests, was performed. The margin-reflex distance (MRD1), levator function, eyelid crease, eyelid contour, and eyebrow position were noted. All patients had normal levator function. The grading of dermatochalasis was done as follows: grade 0: no excess skin, grade 1: mild overhang of skin over eyelid crease, grade 2: excess skin with moderate overhang over eyelid crease, and grade 3: severe excess skin with much of lashes covered[11].

The corneal topography and parameters of total corneal aberration were examined preoperatively and at least one month after the surgery. 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. The same assistant personnel took all measurements without lifting the eyelid during the daytime to prevent diurnal variation. The Sirius topography system (CSO, Florence, Italy) performed corneal topography, noninvasive tear-film breakup time (NI-TBUT), and parameters of total corneal aberration. K1 (anterior corneal surface, flat keratometry), K2 (anterior corneal surface, steep keratometry), Km (anterior corneal surface, average keratometry), central corneal thickness (CCT), anterior chamber volume (ACV), anterior chamber depth (ACD), NI-TBUT, topographic astigmatism (CYL), axis and total corneal optical aberration data (RMS-HOA, RMS-coma, RMS-trefoil, RMS-spherical aberration and RMS-quadrifoil) were compared preoperatively and at least 1 month postoperatively. Internal software automatically produces corneal wavefront data from aberrometry readings using Zernike polynomials (Figure 1). The topography device produces total aberrations based on four different pupil sizes (3, 5, 6, and 7 mm). For analysis standardization, all Zernike coefficients and root mean square (RMS) values for 6-mm pupil size were calculated for all eyes, and Zernike coefficients higher than fifth order were not determined.

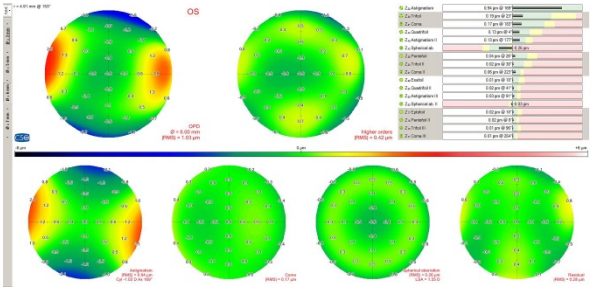

Figure 1.
Sirius aberrometer output display for anterior corneal-higher order aberrations.

Surgical technique

The same experienced oculoplastic surgeon (D.D.) performed upper eyelid blepharoplasty under local anesthesia. The surgical area was cleaned with 10% povidone-iodine solution, and the area was covered with sterile drapes. The lower incision line was marked at the supratarsal crease. The redundant skin was grasped with smooth forceps along the lid crease incision, and the superior incision line was marked. Then, incision lines were merged. Lidocaine HCL

(20mg/mL) and epinephrine (0.0125mg/mL) were injected subcutaneously into the eyelids. An incision was made with a scalpel blade. The skin and subcutaneous tissue were excised with curved, sharp-tipped scissors. After hemostasis using hand cautery, the skin of both sides was sutured with interrupted 6.0 polyglactin. Sutures were removed on postoperative day 7-10 (Figure 2).

Figure 2.
Photograph of a patient with upper eyelid blepharoplasty surgery, taken 1st month after the procedure and on the day the sutures were removed.

Statistical analysis

Statistical analyses were performed using the SPSS software version 22 (IBM Corp., Armonk, NY, USA). Variables were examined using Shapiro-Wilk's test to determine distribution. Continuous data are presented as mean ± standard deviation. Categorical characteristics are presented as numbers (%). The paired sample t-test was performed to compare preoperative and postoperative values, and p-value of <0.05 was considered statistically significant.

Results

Eighty eyelids with dermatochalasis from 40 patients (36 female and 4 male) with a mean age of 51.82±9.95 (32-69) years were included in the study. The mean MRD1 of the patients was 3.03±0.62 mm (2-4) preoperatively, 3.20±0.43 mm postoperatively (p<0.001). The levator function of the patients 15.09±0.62 mm (11-20) preoperatively, 16.01±0.11 mm (11-20) postoperatively (p=0.326). The mean eyelid crease was 10.60±1.86 mm (8-15) preoperatively, 11.07±1.80 mm (9-15) postoperatively (p<0.001). There was no eyebrow ptosis. The dermatochalasis patients were categorized as grade 1 (n=50), grade 2 (n=26), and grade 3 (n=4). Fat excision was performed for 64 eyelids (80%).

The preoperative logMAR BCVA was 0 in 34 eyes (42.5%), 0.045 in 17 eyes (21.25%), 0.096 in 11 eyes (13.75%), 0.154 in 8 eyes (8%), and 0.221 in 10 eyes (12.5%). Postoperative visual acuity improved in 20 eyes (25%). Preoperative BCVA (logMAR) was 0.026±0.886 (0-0.096), and postoperative BCVA (logMAR) was 0.017±1.096 (0-0.070) (p=0.150).

The mean Schirmer I value of the patients was 14.94±7.05 mm (6-25) preoperatively and 15.77±6.56 mm (7-24) postoperatively (p=0.308). The preoperative NI-TBUT value was 9.71±4.47 s (5.70-20), and the postoperative NI-TBUT value was 10.15±4.48 s (5.50-21) (p=0.301).

Topographic data in the preoperative and postoperative periods is presented in Table I. There were no statistically significant differences between the preoperative and postoperative values of K1 (43.32±1.40, 43.32±1.02, p=0.451), K2 (44.23±1.20, 44.11±1.08, p=0.516), K avg (43.77±1.39, 43.88±1.25, p=0.243), CYL (0.90±0.67, 0.79±0.61, p=0.075), axis (80.47±74.56, 94.73±76.58, p=0.168), CCT (541.55±0.32,540.77±0.32, p=0.536) and ACD (2.82±0.39, 2.83±0.37, p=0.781). While preoperative ACV was 122.06±28.0 mm^3, the postoperative ACV was 126.23±28.80 mm^3 (p=0.045).

Table I. Corneal topographic data in the preoperative and postoperative 1st month.

	Preoperative Mean ± SD	Postoperative Mean ± SD	p-value
Flattest keratometry (K1) (D)	43.32±1.40	43.32±1.02	0.451
Steepest keratometry (K2) (D)	44.23±1.20	44.11±1.08	0.516
Mean Keratometry (Kmean) (D)	43.77±1.39	43.88±1.25	0.243
Anterior Corneal Astigmatism (D)	0.90±0.67	0.79±0.61	0.075
Axis	80.47±74.56	94.73±76.58	0.168
Central corneal thickness (µm)	541.55±0.32	540.77±0.32	0.536
Anterior Chamber Volume (mm^3)	122.06±28.0	126.23±28.80	**0.045***
Anterior Chamber Depth (mm)	2.82±0.39	2.83±0.37	0.781

D: Diopter. Paired sample t-test, p<0.05 statistically significant. Results are denoted as mean ± standard deviation (range)

*statistically significant

Wavefront aberration data for the total corneal surface in the preoperative and postoperative periods is presented in Table II. The RMS-HOA in the 6 mm optical zone was 0.331±0.115 µm, which decreased significantly to 0.255±0.106 µm (p<0.001). The RMS-Coma (Z_3^1), (0.193±0.102, 0.181±0.190, p=0.841), RMS-Trefoil (Z_3^3) (0.152±0.114, 0.151±0.101,

p=0.866), and RMS-Quadrifoil (Z_4^4) (0.078±0.073, 0.077±0.106, p=0.932) values were found similar. The RMS-spherical aberration (Z_4^0) decreased significantly after upper eyelid blepharoplasty (0.398±0.301, 0.371±0.280, p=0.035).

Table II. Wavefront aberration data for the total corneal surface in the preoperative and postoperative 1st month.

	Preoperative Mean ± SD	Postoperative Mean ± SD	p values
RMS-HOA (µm)	0.331±0.115	0.255±0.106	**<0.001***
RMS-Coma (Z_3^1), (µm)	0.193±0.102	0.181±0.190	0.841
RMS-Trefoil (Z_3^3) (µm)	0.152±0.114	0.151±0.101	0.866
RMS-Spherical aberration (Z_4^0) (µm)	0.398±0.301	0.371±0.280	**0.035***
RMS-Quadrifoil (Z_4^4)	0.078±0.073	0.077±0.106	0.932

RMS: Root mean square, HOA: High-order aberrations, Paired sample t-test, p<0.05 statistically significant. Results are denoted as mean ± standard deviation (range)

*statistically significant

Changes in RMS-HOA and RMS-spherical aberration after upper eyelid blepharoplasty are shown in Figure 3.

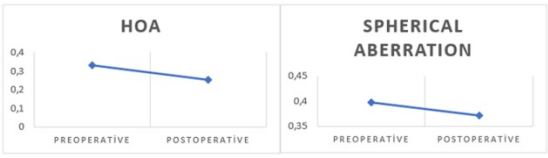

Figure 3.
Changes in HOA and Spherical aberration After Upper Eye Lid Blepharoplasty.

Discussion and Conclusion

After UEB, removing the excess skin and decreasing sagging fat pressure on the upper part of the eyelids can cause changes in corneal curvature. A study found a reduction in K2 and an increase in Km postoperatively[12]. In a different study, K1 and K2 changes were similar, and preoperative astigmatism, which was 0.67 D, decreased to 0.48 D[13]. Brown et al. found that the mean dioptric change at 1 and 3 months after UEB was 0.49D and 0.57 D, respectively[14]. Zinkernagel et al. stated that the astigmatic change in the fat-removal blepharoplasty group was statistically significantly higher than in the skin-only blepharoplasty group[15]. This may suggest that the severity of the upper eyelid abnormality responds to topographic changes in the cornea. In the present study, dry eye parameters, K1, K2, Km, topographic astigmatism and axis were similar postoperatively. Corneal astigmatism decreased 0.11 D in this study, which was lower than in the literature. The possible reason for this may be that our patient group was younger (51.82 years) compared to other studies, and 96% had grade 1 and grade 2 dermatochalasis.

Dry eye symptoms may be exacerbated following blepharoplasty due to several factors, such as chemosis, postoperative inflammation, lagophthalmos, excess orbicularis resection and denervation, eyelid retraction, and malfunction of the lacrimal pumping system. However, Kim et al. in their study evaluated corneal sensitivity and Schirmer's test before and after blepharoplasty and blepharoptosis surgery; they reported that corneal sensitivity and the Schirmer test showed a statistically significant increase in the 1st month[16]. Another study investigated the effects of UEB and blepharoptosis surgery on the ocular surface at 1 day, 1 week, 1 month, 3 months, and 6 months postoperatively. It was reported that the decrease in invasive TBUT value at 1 week in the group that only underwent ptosis surgery returned to normal in the first month. However, it was observed that the decrease in Schirmer's test continued at 6 months in the group in which blepharoplasty was performed alone or in combination with ptosis surgery[17]. In this study, the Schirmer I test and NI-TBUT changes were not significant in the postoperative 1st month.

In this study, ACV increased postoperatively, but the increase in ACD was not statistically significant. Ilhan et al. found that ACD and axial length did not change in three different groups in the third month after UEB[18]. Koc et al. found that the mean ACD was 2.90±0.37 mm preoperatively, 3.00±0.29 mm on the postoperative first day, and 3.04±0.29 mm on the postoperative seventh day[19]. We speculate that the postoperatively reshaped eyelid skin may deepen the center of the anterior chamber by reducing the vectorial forces and tensions applied to the anterior chamber.

The present study examined visual acuity and HOAs among the functional results of UEB. As Altin Ekin et al. reported, the slight increase in visual acuity was not statistically significant[12]. Bhattacharjee et al. showed no change in the visual acuity after UEB in the early postoperative period[13]. While 0, 1st, and 2nd-order aberrations in Zernicke polynomials are defined as RMS low-order aberrations (LOAs), third-degree and above aberrations are defined as RMS-HOAs[9,10]. Eighty-five percent of wavefront defects are LOAs, and 15% are HOAs[20]. HOAs are an index of visual quality, and their reduction increases contrast sensitivity[12]. A study suggested decreased RMS of total HOAs and vertical and horizontal trefoil and coma after chalazion curette[21]. Han et al. reported that preoperative third-order and coma-like aberrations

were significantly more common in the ptosis repair group than in the blepharoplasty group; both decreased significantly after the operation[22]. Kim JW et al. found that HOAs improved one month after UEB surgery[6]. Lee et al. suggested epiblepharon surgery significantly reduced fourth-order aberrations and tetrafoil in the 4 mm zone and coma, tetrafoil, and secondary astigmatism in the 6 mm zone[23]. A different study examined 60 eyes of 30 blepharoplasty patients and found decreased total HOA and total coma for 4-mm and 6-mm pupil size[2]. We found that the RMS-HOA and RMS-spherical aberration decreased for 6-mm pupil size after UEB. In the Zernike polynomials, aberrations closer to the center (e.g., coma and spherical aberration) affect the quality of vision more than those closer to the edge (e.g., trefoil, tetrafoil). Spherical aberration is a fourth-order aberration that varies depending on the radial distance measured from the center of the pupil. While an optical system does not have a refractive error in the center of the pupil, the defect may increase in the circular zones surrounding the center of the pupil[24,25]. While the resulting image is sharp for a small pupil diameter, it becomes distorted as the pupil expands. Although we did not evaluate pupil diameter, one reason the postoperative spherical aberration decreased in this study may be that light enters the eye, touches the lash ptosis, and undergoes diffraction[6]. Besides, LOA and HOA increase as participants narrow their palpebral fissures[26]. In the present study, after UEB, MRD1 increased significantly. This may also have a reducing effect on hoa and spherical aberration. Tzelikis et al. stated that reduced spherical aberration increases contrast sensitivity and visual quality[27]. Spherical aberrations were determined to be significant for contrast sensitivity, visual quality, and depth perception. If spherical aberrations increase, the patient's night vision and especially contrast sensitivity decrease, and glare and halo complaints increase[28].

The study's limitations include being done in a single center, having a short follow-up period, and not measuring contrast sensitivity and pupil diameter. Additionally, due to the irregularity in the distribution of the number of patients, it was not possible to compare the group in which only skin was removed and the group in which skin and fat were removed. Also, the amount of excised skin was not measured in this study. More objective data can be obtained by comparing the amount of skin removed and aberration changes in future studies. The strength of our study is its prospective nature and the management of patients by the same experienced surgeon.

In conclusion, UKB surgery can improve the topographic and aberrometry measurements of the cornea in the early postoperative period.

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Idea and design: A.S.I., D.D.; Data collection and processing: A.S.I., D.D., M.Y.; Analysis and interpretation of data: A.S.I., D.D.; Writing of significant parts of the article: A.S.I., D.D., M,Y.

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References

1. Damasceno RW, Avgitidou G, Belfort R Jr, et al. Eyelid aging: pathophysiology and clinical management. Arq Bras Oftalmol 2015; 78:328-31.
2. Bhattacharjee K, Misra DK, Deori N. Updates on upper eyelid blepharoplasty. Indian J Ophthalmol 2017;65:551-8.
3. Jacobs LC, Liu F, Bleyen I, et al. Intrinsic and extrinsic risk factors for sagging eyelids. JAMA Dermatol 2014; 150:836–43.
4. Meyer DR, Stern JH, Jarvis JM, Lininger LL. Evaluating the visual field effects of blepharoptosis using automated static perimetry. Ophthalmology 1993;100:651–8.
5. Hacker HD, Hollsten DA. Investigation of automated perimetry in the evaluation of patients for upper lid blepharoplasty. Ophthal Plast Reconstr Surg 1992; 8:250–5.
6. Kim JW, Lee H, Chang M, et al. What causes increased contrast sensitivity and improved functional visual acuity after upper eyelid blepharoplasty? J Craniofac Surg 2013;24:1582-5.
7. 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(5): 263–7
8. Atalay K, Gurez C, Kirgiz A, Serefoglu Cabuk K. Does severity of dermatochalasis in aging affect corneal biomechanical properties? Clin Interv Aging 2016;11:659-64.
9. Su T, He Y, Liu S, et al. Transient Increase of Wavefront Aberrations after Horizontal Rectus Muscle Surgery in Exotropia. Curr Eye Res 2019;44(12):1393-8.
10. Rudolph M, Laaser K, Bachmann BO, et al. Corneal higher-order aberrations after Descemet's membrane endothelial keratoplasty. Ophthalmology 2012;119(3):528-35.
11. Shah M, Lee G, Lefebvre DR, et al. A cross-sectional survey of the association between bilateral topical prostaglandin analogue use and ocular adnexal features. PLoS One 2013; 1;8(5):e61638.
12. Altin Ekin M, Karadeniz Ugurlu S. Prospective analysis of visual function changes in patients with dermatochalasis after upper eyelid blepharoplasty. Eur J Ophthalmol 2019;30(5):978-84.
13. Bhattacharjee K, Misra D, Singh M, Deori N. Long-term changes in contrast-sensitivity, corneal topography and higher-order aberrations after upper eyelid blepharoplasty: A prospective interventional study. Indian J Ophthalmol 2020;68(12):2906-10.
14. Brown MS, Siegel IM, Lisman RD. Prospective analysis of changes in corneal topography after upper eyelid surgery. Ophthalmic Plast Reconstr Surg 1999;15(6):378-383.
15. Zinkernagel MS, Ebneter A, Ammann-Rauch D. Effect of upper eyelid surgery on corneal topography. Arch Ophthalmol 2007;125(12):1610-2.

16. 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.
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.
18. Ilhan C, Aydemir GA, Aydemir E. Changes in Intraocular Pressure and Ocular Biometry After Blepharoplasty. Aesthetic Plast Surg 2022;46(5):2295-300.
19. Koc H, Ozen S, Bayram U, Kanik A. Evaluation of early period changes in intraocular pressure, ocular biometry and anterior segment after upper eyelid blepharoplasty. Int Ophthalmol 2024; 3;44(1):2.
20. Applegate RA. Glenn Fry award lecture 2002: Wavefront sensing, ideal corrections and visual performance. Optom Vis Sci 2002; 81:167-77.
21. Sabermoghaddam AA, Zarei-Ghanavati S, Abrishami M. Effects of chalazion excision on ocular aberrations. Cornea 2023;32(6): 757–60.
22. 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(10):814-22.
23. Lee H, Jang S, Park M, Park J, Baek S. Effects of epiblepharon surgery on higher-order aberrations. JAAPOS 2016;20:226-31.
24. Rabinowitz YS. The genetics of keratoconus. Ophthalmol Clin North Am 2003;16:607-20.
25. Applegate RA, Sarver EJ, Khemsara V. Are all aberrations equal? J RefractSurg 2001;18:556-62.
26. Han W, Kwan W, Wang J, et al. Influence of eyelid position on wavefront aberrations. Ophthalmic Physiol Opt 2007;27:66–75.
27. Tzelikis PF, Akaishi L, Trindade FC, Boteon JE. Spherical aberration andcontrast sensitivity in eyes implanted with aspheric and spherical intraocularlenses: a comparative study. Am J Ophthalmol 2008;145:827-33.
28. Kuroda T, Fujikado T, Maeda N, Oshika T, Hirohara Y, Mihashi T. Wavefront analysis of higher-order aberrations in patients with cataract. J CataractRefract Surg 2002;28:438-44.13.