The European Research Journal 2025;11(1):98-104 Original Article
DOI: https://doi.org/10.18621/eurj.1596476 *Ophthalmology*

Corneal topographic and aberrometric changes in patients with acquired blepharoptosis after levator resection surgery

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ABSTRACT

Objectives: To evaluate changes in corneal topography and aberrometry in patients with acquired blepharoptosis after levator resection surgery.
Methods: This prospective, interventional study evaluated 30 eyelids of 19 patients who underwent levator resection surgery for acquired blepharoptosis with fair and good levator function (LF). Patients underwent corneal topography before and 3 months after surgery.
Results: Eleven patients had bilateral, and 8 patients had unilateral surgery. There were significant decreases in steep keratometry (K2) (preoperative: 46.21±5.02, postoperative: 44.58±2.11, P=0.046) and corneal astigmatism (preoperative: 2.98±0.61, postoperative: 1.59±1.50, P=0.034). There were no statistically significant differences between the preoperative and postoperative values of flat keratometry (K1) (P=0.585), mean keratometry (Kmean) (P=0.122), axis of corneal astigmatism (P=0.548), central corneal thickness (P=0.350), anterior chamber depth (P=0.747) and anterior chamber volume (P=0.679). The root mean square (RMS)-higher order aberrations (HOA) (P<0.001), RMS-Coma (Z_3^1) (P<0.001), and RMS-Trefoil (Z_3^3) (P=0.005) decreased significantly. Preoperative and postoperative values of the seconder astigmatism (P=0.345), RMS-spherical aberration (Z_4^0) (P=0.255), and RMS-Quadrafoil (Z_4^4) values were found similar.
Conclusions: Levator resection for acquired blepharoptosis can improve the topography and aberrometry measurements of the cornea 3 months after surgery.
Keywords: Blepharoptosis, levator resection surgery, corneal topography, corneal higher-order aberrations, RMS-HOA, dry eye

Blepharoptosis, also known as “ptosis,” is the unilateral or bilateral drooping of the upper eyelid in the primary gaze position of the eye. It is classified as congenital or acquired. Congenital ptosis is a myogenic origin in which the levator muscle improperly develops and occurs at birth or in the first year of life. Acquired ptosis appears later and can be sub-classified: neurogenic, myogenic, aponeurotic, mechanical, and traumatic. The most common is aponeurotic ptosis, which develops due to involutional changes, dehiscence, or disinsertion of aponeurosis [1, 2]. The estimated prevalence of ptosis in the adult population varies between 4.7% and 13.5% [3-5].

Blepharoptosis may cause both appearance-related

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How to cite this article: Sariyeva Ismayilov A, Doğanay D, Yelkovan M. Corneal topographic and aberrometric changes in patients with acquired blepharoptosis after levator resection surgery. Eur Res J. 2025;11(1):98-104. doi: 10.18621/eurj.1596476

Received: December 4, 2024
Accepted: December 26, 2024
Published Online: December 30, 2024

anxiety and poor visual quality [6, 7]. In patients with blepharoptosis, visual field loss, refraction changes, and decreased contrast sensitivity have been shown [8-10].

Depending on the severity of blepharoptosis and levator function (LF), various surgical procedures, including levator resection, frontalis suspension, mullerectomy, and Fasanella-Servat are applied in the treatment [11-13]. Many ocular surgeons prefer levator resection in eyes with LF greater than 4 mm, and most of them believe that levator resection results in a better lid contour and position than frontalis suspension [14]. It has been reported that after the levator procedure, the mean corneal astigmatism decreased by 0.25 diopters (D), and contrast sensitivity improved significantly postoperatively [15, 16].

Levator resection surgery may affect corneal topography and higher-order aberrations (HOAs) since it eliminates the effect of the drooping upper eyelid on the ocular surface and corneal curvature. In particular, the impact of levator resection surgery on HOAs is not fully understood, and there are few studies on this subject in the literature. The present study evaluated changes in corneal topography and aberrometry in patients with acquired blepharoptosis after levator resection surgery.

METHODS

This prospective, interventional study evaluated 30 eyelids of 19 patients who underwent levator resection surgery for acquired blepharoptosis with fair and good LF at a single center between June 2023 and December 2024. The ptosis of all included patients was characterized by aponeurotic ptosis. The hospital's local ethics committee approved the study (number: 2011-KAEK-25 2023/05-14-31.05.2023). The study adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from each patient before surgery.

The patients underwent a routine ophthalmologic examination, including best corrected visual acuity (BCVA) (Snellen's chart and converted to the logarithm of the minimal angle of resolution (logMAR)), intraocular pressure (IOP), and biomicroscopic examination. Schirmer strips were used for the Schirmer I test in the outer third of the lower lid fornix without topical anesthesia, and the wet distance was measured after 5 minutes. It was considered abnormal if the measurements were ≤10 mm [17]. Tear breakup time (TBUT) was measured after using fluorescein dye as the time between the last blink and the first break in the dye on the cornea under biomicroscopic examination at x10 magnification with a cobalt blue filter. If the TBUT measurements were <5 s, it was interpreted as suggestive of dry eye [18].

Patients with gross eyelid pathologies other than acquired blepharoptosis, such as entropion or ectropion, previous corneal or eyelid surgery, pterygium, keratoconus, any corneal opacity, wearing contact lenses, strabismus, or syndromes such as Marcus Gunn jaw winking syndrome were excluded.

Blepharoptosis Evaluation

The position of the upper eyelid was evaluated in the primary gaze. Margin-reflex distance 1 (MRD1) is the distance between the upper eyelid margin and the corneal central light reflex in the primary position. Vertical fissure height (VFH) is the distance between the upper and lower lid margin. LF was determined by asking the patient to look up and down while pressing on the eyebrow and measuring the excursion of the upper eyelid margin. The distance ≤ 5 mm was classified as poor, 6-11 mm as fair, and ≥12 mm as good LF [19]. Levator resection was planned for patients with fair to good LF (>5 mm).

Corneal Topographic Measurements

Corneal topography and aberrometry were conducted using the Sirius device (CSO, Florence, Italy) before the surgery and 3 months postoperatively. Sirius imaging system combines a rotating Scheimpflug camera and Placido disk technology. Three precisely focused, centered, and aligned images were captured for each eye, and patients were instructed to blink twice to ensure a smooth corneal surface and reproducible measurement. To ensure uniformity in measurements, the upper eyelid was mechanically lifted in all eyes immediately before the aberrometry examination to visualize the centers of gravity. The same experienced technician took all measurements. To minimalize diurnal vaiations, all measurements were taken between 9 AM and 12 AM. The daytime to prevent diurnal variation. K1 (anterior corneal surface, flat keratometry), K2 (anterior corneal surface, steep keratometry), Kmean (anterior corneal surface, mean keratometry), central corneal thickness (CCT), anterior chamber volume (ACV), anterior chamber depth (ACD), corneal astigmatism, axis of corneal astigmatism and total corneal optical aberration data root mean square (RMS)-HOA, RMS-Coma, RMS-Trefoil, Seconder astigmatism, RMS-Spherical aberration and RMS-Quadrafoil were compared preoperatively and at least 3 months postoperatively. Internal software automatically produces corneal wavefront data from aberrometry readings using Zernicke polynomials. The topography device produces total corneal aberrations based on four different pupil sizes (3, 5, 6, and 7 mm). For analysis standardization, all Zernicke coefficients and RMS values for 6-mm pupil size were evaluated for all eyes, and Zernicke coefficients higher than fifth order were not determined.

Surgical Technique

The same oculoplastic surgeon (D.D.) performed levator resection surgery under local anesthesia. The site of the proposed lid crease was marked. Lidocaine hydrochloride (20 mg/mL) and epinephrine (0.0125 mg/mL) were injected subcutaneously into the eyelid. After the skin and orbicularis oculi incision, the orbital septum was opened to expose preaponeurotic fat, a landmark for the levator muscle. Preaponeurotic fat retracted and levator muscle exposed. The levator muscle was separated from its insertion. Double-armed 6-0 coated polyglactin 910 (Vicryl) sutures passed through the tarsus. Eyelid position was evaluated intraoperatively. The measured excess part of the muscle was resected. The skin and orbicularis were closed.

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. The distribution of the data was normal. 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

Thirty eyelids with acquired blepharoptosis from 19 patients (7 females and 12 males) with a mean age of 65.25±15.12 (range: 24-82) years were included in the study. The mean MRD1 of the patients was 0.69±0.90 mm (range: 0-3) preoperatively and 3.86±1.23 (range: 3-7) mm postoperatively (P<0.001). The mean VFH was 6.57±2.74 (range: 3-12) mm preoperatively and 10.33±2.45 mm (range: 6-17) postoperatively (P<0.001). The LF of the patients were 10.68±3.85 mm (range: 6-17) preoperatively and 14.01±0.11 mm (range: 7-20) postoperatively (P=0.045). Preoperative BCVA (logMAR) was 0.187±0.508 (range: 0-0.096), and postoperative BCVA (logMAR) was 0.141±0.602 (range: 0-0.070) (P=0.652).

The patients' mean Schirmer I test results were 14.95±8.07 mm (range: 10-20) preoperatively and 15.65±6.65 mm (range: 10-14) postoperatively

Table 1. Topographic data in the preoperative and postoperative 3-month

	Preoperative	Postoperative	P value
Flattest keratometry (K1) (D)	43.10±1.47	42.97±1.47	0.585
Steepest keratometry (K2) (D)	46.21±5.02	44.58±2.11	**0.046**
Mean keratometry (Kmean) (D)	44.44±2.45	43.73±1.37	0.122
Corneal astigmatism (D)	2.98±0.61	1.59±1.50	**0.034**
Axis of corneal astigmatism	74.50±61.76	82.83±62.80	0.548
Central corneal thickness (µm)	533.80±51.66	528.15±52.43	0.350
Anterior chamber volume (mm^3)	137.32±47.65	139.72±46.44	0.679
Anterior chamber depth (mm)	2.98±0.59	2.99±0.58	0.747

Data are shown as mean±standard deviation. D=Diopter.
Paired sample t-test, P<0.05 statistically significant.

Table 2. Corneal aberration data in the preoperative and postoperative 3-month

	Preoperative	Postoperative	P value
RMS-HOA	2.271±0.815	1.241±0.591	**<0.001**
RMS-Coma (Z_3^1)	2.941±0.731	0.424±0.642	**<0.001**
RMS-Trefoil (Z_3^3)	2.054±1.425	0.583±1.265	**0.005**
Seconder Astigmatism	0.768±1.852	0.284±0.915	0.345
RMS-Spherical aberration (Z_4^0)	0.510±0.835	0.365±0.511	0.255
RMS-Quadrafoil (Z_4^4)	1.928±5.371	1.549±1.536	0.715

Data are shown as mean±standard deviation. RMS=Root mean square, HOA=High-order aberrations, Paired sample t-test, P<0.05 statistically significant.

(P=0.405). The preoperative mean TBUT was 6.76±4.63 s (6-15), and the postoperative mean TBUT was 7.88±6.75 s (range: 6-16) (P=0.554).

Topographic data in the preoperative period and in the postoperative 3rd month are presented in Table 1. There were no statistically significant differences between the preoperative and postoperative values of K1 (43.10±1.47 and 42.97±1.47, respectively; P=0.585), K mean (44.44±2.45 and 43.73±1.37, respectively; P=0.122), axis of corneal astigmatism (74.50±61.76 and 82.83±62.80, respectively; P=0.548), CCT (533.80±51.66 and 528.15±52.43, respectively; P=0.350), ACD (2.98±0.59 and 2.99±0.58, respectively; P=0.747) and ACV (137.32±47.65 and 139.72±46.44 mm3, respectively; P=0.679) parameters. While preoperative K2 was 46.21±5.02, the postoperative K2 was 44.58±2.11 (P=0.046). Preoperative corneal astigmatism was 2.98±0.61, and postoperative corneal astigmatism was 1.59±1.50 (p=0.034).

Wavefront aberration data for the total corneal surface in the preoperative period and in the postoperative 3rd month are presented in Table 2 and Fig. 1. The RMS-HOA in the 6 mm optical zone was 2.271±0.815 µm, which decreased significantly to 1.241±0.591 µm (P<0.001). The RMS-Coma (Z_3^1) was 2.941±0.731 µm, which significantly reduced to 0.424±0.642 µm (P<0.001). While preoperative RMS-Trefoil (Z_3^3) was 2.054±1.425 µm, postoperative RMS-Trefoil (Z_3^3) was 0.583±1.265 µm (P=0.005). Preoperative and postoperative values of the seconder astigmatism (P=0.345), RMS-spherical aberration (Z_4^0) (P=0.255), and RMS-Quadrafoil (Z_4^4) (P=0.715) values were found similar.

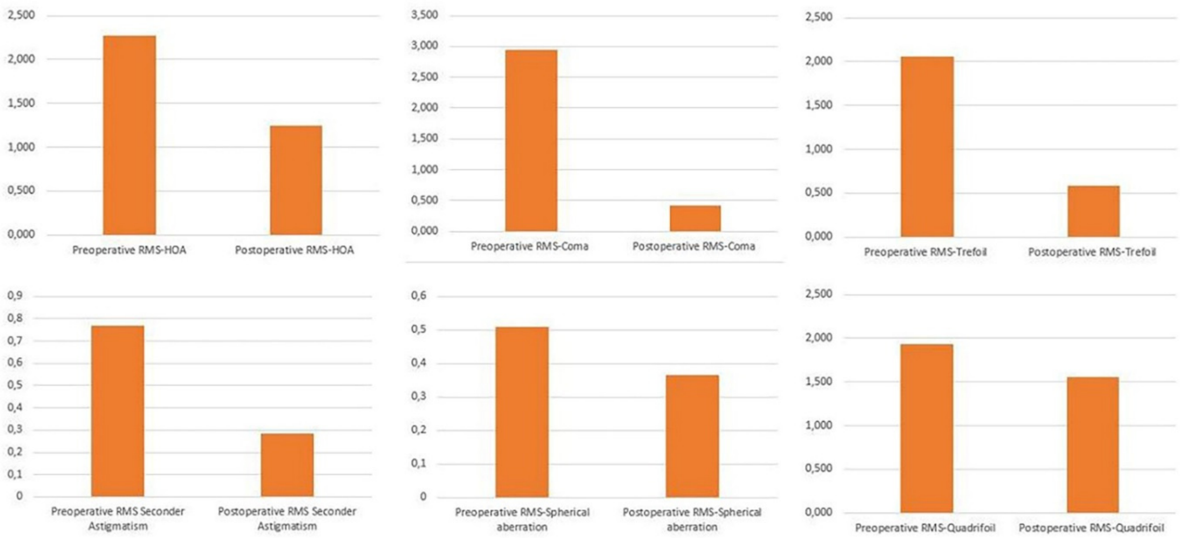

Fig. 1. Changes in corneal HOAs postoperatively.
(RMS=Root mean square, HOA=High-order aberrations)

DISCUSSION

Levator resection surgery may improve visual function by removing the eyelid covering the pupil and changing corneal shapes [20]. It may modify the pressure on the opposing cornea and alter preexisting corneal curvature. This study investigated the effects of levator resection surgery on corneal topography in patients with acquired blepharoptosis. Cadera *et al*. [21] found that 36% of the study eyes' astigmatism changed by more than 0.75 D. Their results were similar for both fascia lata sling and levator resection [21]. Garima *et al*. [22] reported that the mean preoperative astigmatism was 1.28 D while the mean postoperative astigmatism was 1.71 D. Another study showed an average decrease of 0.18 D in astigmatism after congenital ptosis surgery [23]. This study found that postoperative corneal astigmatism decreased statistically significantly by an average of 1.39 D. In addition, it was observed that both K1 (from 43.10±1.47 to 42.97±1.47) and K2 (from 46.21±5.02 to 44.58±2.11) decreased postoperatively. The decrease in K2 was statistically significant. Our results matched the results of Islam *et al*. [24] found that K1 decreased from 43.00±1.28 preoperatively to 42.88±1.37 postoperative, and K2 decreased from 44.11±1.22 preoperatively to 43.99±1.44 postoperative. In another study, K1 and K2 changes in the 1st and 3rd months after ptosis surgery were not found to be significant [25]. These heterogeneous results of ptosis surgery on the cornea may depend on the type of topography devices used, the age of the patients (congenital or acquired), different races (eyelid morphology), and different follow-up periods.

Third-order and above aberrations are defined as RMS-HOAs. HOAs are an index of visual quality, and their reduction increases contrast sensitivity [26]. The anterior corneal surface is an essential contributor to the total HOAs of the eye. The impact on the corneal shape of the eyelid is mainly exerted on the anterior ocular surface. Shen *et al*. [27] reported that both the vertical coma and the vertical trefoil of the anterior corneal HOAs showed a significant difference between the ptosis and control groups. The upper eyelid pressure exerted on the cornea in a vertical direction is the likely optical explanation for the significant increase in vertical corneal aberrations since the upper eyelid drops. At the end of this study, it was observed that RMS-HOA, RMS-Coma, RMS-Trefoil, secondary astigmatism, RMS-Spherical aberration, and RMS-Quadrafoil decreased in the 3rd postoperative month. However, the decreases in RMS-HOA, RMS-Coma, and RMS-Trefoil were statistically significant. Safari *et al*. [28] reported that ptosis surgery for congenital upper eyelid ptosis corrected vertical coma in aberrometry, and as corneal astigmatism is > 1D, postoperative aberrometric changes are more pronounced. Han *et al*. [29] reported that third-order and coma-like aberrations were significantly reduced in patients who underwent levator resection. As a result, levator resection surgery may positively affect the quality of vision by reducing HOAs.

Upper eyelid surgery may cause postoperative dry eye symptoms by affecting meibomian, lacrimal and auxiliary tear glands, and orbicularis muscle by negatively impacting tear production. However, this effect has been shown to disappear within a few days [30]. For longer follow-ups, postoperative blinking recovery and eye dryness reduction may also improve postoperative HOAs. In this study, the postoperative Schirmer I test and TBUT increased slightly, but this increase was not statistically significant.

Limitations

The study's strengths are that it is prospective and examines dry eye parameters to observe the effect of aberrations. Its limitations are that it is a single-center study with a small sample size and a short follow-up period. Studies with larger patient groups and longer follow-up periods are needed.

CONCLUSION

Levator resection surgery reduced K2, corneal astigmatism, RMS-HOA, RMS-Coma, and RMS-Trefoil values in the postoperative 3rd-month.

Ethical statement

Consent was obtained from the patient. Ethics committee approval (number: 2011-KAEK-25 2023/05-14-31.05.2023) was obtained from the Bursa Yuksek Ihtisas Training and Research Hospital's local ethics committee.

Authors' Contribution

Study Conception: ASI, DD; Study Design: ASI,

MY; Supervision: DD; Funding: ASI; Materials: MY; Data Collection and/or Processing: MY; Statistical Analysis and/or Data Interpretation: ASI; Literature Review: DD; Manuscript Preparation: ASI and Critical Review: DD.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

Financing

The authors disclosed that they did not receive any grant during conduction or writing of this study.

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