Pupillary and Anterior Chamber Changes Following Upper Eyelid Blepharoplasty

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Purpose: This study investigated the preoperative and postoperative pupillary and anterior chamber (AC) characteristics of patients undergoing upper eyelid blepharoplasty.

Methods: This prospective, cross-sectional study examined 32 eyes from 20 dermatochalasis patients. Following a detailed ophthalmological examination, quantitative pupillometry and Scheimpflug corneal topography were used to evaluate the pupil and AC characteristics of eyes on the day of operation and postoperative days 1 and 7. Static and dynamic pupillometry characteristics, including scotopic, mesopic, low photopic, and high photopic pupil diameter (PD), resting diameter, amplitude, latency, duration, and velocity of pupil contraction, and latency, duration, and velocity of pupil dilation, were measured. Additionally, AC volume, depth, and angle parameters were analyzed.

Results: There were significant differences between scotopic, mesopic, and resting PD and the amplitude of pupil contraction. Pairwise comparisons showed that postoperative day 1 scotopic, mesopic, and resting PD and amplitude of pupil contraction measurements were significantly higher than preoperative measurements ($p = 0.008$, $p < 0.001$, $p = 0.006$, and $p = 0.033$, respectively). Additionally, scotopic and resting PD were significantly lower on postoperative day 7 compared with postoperative day 1 ($p = 0.001$ and $p = 0.041$, respectively). However, there were no significant differences in AC parameters.

Conclusions: This study revealed that static and dynamic pupil measurements changed following blepharoplasty, with postoperative increased PD occurring particularly under low-light conditions. Therefore, low-light environments should be avoided following blepharoplasty, and patients with angle-closure risk factors should be closely monitored in the early postoperative period.

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Blepharoplasty is a common facial plastic surgery performed for both functional and aesthetic purposes. The surgery involves excision of the excessive eyelid skin, muscle, and fat arising from age-related anatomical changes and is performed under local or general anesthesia. Safe and successful blepharoplasties require a detailed preoperative examination, attention to intraoperative surgical techniques, and sufficient postoperative care.

Blepharoplasty has rare but severe surgical complications, such as retrobulbar hemorrhage and glaucoma, which can result in permanent vision loss.[1,2] Several studies have reported the development of acute primary angle closure (PAC) following blepharoplasty.[2,3] Wride and Sanders[4] described a blepharoplasty-associated case of complete vision loss resulting from acute angle closure glaucoma (ACG). This complication can be triggered by various factors, including the supine position during surgery, emotional stress, and pharmacologically induced mydriasis, and its occurrence is increased by certain risk factors, such as narrow anterior chamber (AC) angle, plateau iris, and hyperopia.[5–7] In addition, age, sex, and ethnicity have also been found to predispose patients to PAC, with the elderly, females, and Asians disproportionally affected. As such, a preoperative and postoperative examination of the pupil and AC is necessary to prevent the development of PAC.

While blepharoplasty-associated PAC and pupil dilation have been reported,[2,7] there have been no objective, quantitative investigations into the pupillary alterations and AC characteristics of blepharoplasty patients. To address this deficiency, this study investigated the preoperative and postoperative pupillary and AC features of patients who underwent upper eyelid blepharoplasty using automatic pupillometry and Scheimpflug corneal topography.

METHODS

Study Design and Participants. This prospective, cross-sectional study was performed in the oculoplastic department at a single tertiary eye hospital between October 2019 and February 2020. The study was approved by the Institutional Ethics Committee and conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants.

Exclusionary criteria included a history of ocular or head trauma, prior ocular or orbital surgery, prior laser surgery, known or suspected ocular hypertension or glaucoma, intraocular pressure (IOP) measurements >21 mm Hg, pseudoexfoliation or pigment dispersion syndrome, plateau iris, grade 1 and 2 AC angle by the van Herick method, and a spherical equivalent of refractive error >1.5 diopters. Participants with factors expected to affect automated pupillometry and Scheimpflug corneal topography measurements, such as corneal scarring, corneal ectasia, dry eye syndrome, mature cataracts, pupil anomalies, anisocoria, diabetes mellitus, neurological diseases, smoking, and systemic or topical medical treatments (e.g., tropicamide, cyclopentolate, pilocarpine, antiprostate drugs, and narcotic-derived medications), were also excluded from the study.

Ophthalmic Examination. All participants underwent a detailed ophthalmological examination, including a best-corrected visual acuity measurement using a Snellen chart, biomicroscopic anterior segment exami-

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The authors have no financial or conflicts of interest to disclose.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Ankara Training and Research Hospital and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent was obtained from all individual participants included in the study.

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nation, IOP measurement using Goldmann applanation tonometry, and dilated fundus examination. Refraction measurements were performed using a single automatic refractor-keratometer (RF-K2 Full Auto Ref-Keratometer, Canon Inc., Tokyo, Japan). The presence of relative afferent pupil defects was examined using the swinging-*flashlight* test.

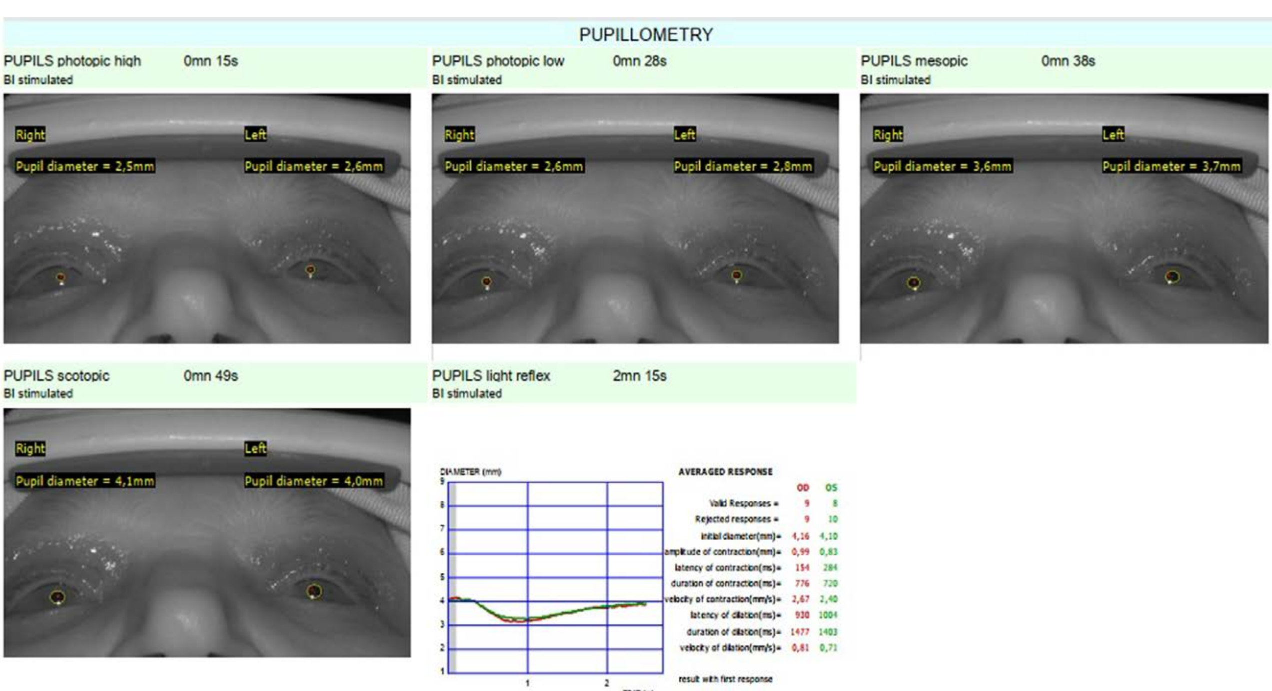
Surgical Technique. While in a seated position, eyelid folds and borders of excessive skin were marked prior to administration of local anesthetics to minimize the effects of anesthesia-induced skin distortion. The face was then covered with sterile draping, excluding the surgical area. Blepharoplasty was performed under local anesthesia by subcutaneous infiltration of a local anesthetic and vasoconstrictor (1 ml of 2 % lidocaine solution containing a 1:100,000 dilution of epinephrine/eyelid). Seven minutes after injection, skin incision and excision were performed using an electrosurgical device (EK-160, Üzümcü, Ankara, Turkey). Upper eyelid skin closure was performed using 6.0 vicryl sutures. The same surgeon (E.M.S.) performed the operations on each patient using the same piece of equipment. Only the surgical area of upper eyelids was closed postoperatively (not including the pupil) to minimize the effects of eye closure on pupil changes, and topical fusidic acid ointment was prescribed. Patients were advised to keep their head elevated while sleeping using two to three pillows and cool their upper eyelids for 15 min/h while awake.

Corneal Topography Measurements. A single experienced technician performed all AC examinations using a Scheimpflug corneal topography system (Pentacam HR, OCULUS Optikgeräte GmbH, Wetzlar, Germany). No contact ocular examination or pupil dilation was performed before examination. To obtain a reflex-free image, all measurements were performed under dim-light conditions using the automatic-release mode to reduce examiner-dependent errors. The patient was correctly positioned in front of the Scheimpflug camera to observe a black fixation target. AC depth (ACD), AC volume, and AC angle were obtained using a rotating Scheimpflug camera system. Scans with a quality factor <95 % were excluded from the study. To minimize effects from diurnal changes in the cornea, Scheimpflug imaging was performed within the same time period (between 8:00 AM and 9:00 AM) and under the same environmental conditions. Measurements were performed on the day of operation (preoperative), postoperative day 1, and postoperative day 7. A single experienced grader (E.M.S.) reviewed all of the Pentacam HR images.

Pupillometry Measurements. A single experienced technician performed pupillometry measurements using the same automatic quantitative pupillometry system (MonPackONE, Vision Monitor System, Metrovision, Pérenchies, France). Pupils were not dilated before examination. The MonPackONE vision monitor system allows for measurements to be obtained from both pupils under complete darkness with precise control of the stimulation. Both static and dynamic pupillometry measurements and accurate pupil size measurements can be acquired. Three consecutive measurements were taken for each patient, with the average value used for the analysis. The device's automatic-release mode was used to prevent examiner-induced errors.

The proprietary analysis software of the device was used to conduct automatic static and dynamic pupillometry. Static pupillometry measurements were obtained under various illuminations, including scotopic (0.1 cd/m^2), mesopic (1 cd/m^2), low photopic (10 cd/m^2), and high photopic (100 cd/m^2) pupil diameter (PD) (Fig.). Dynamic pupillometry measurements were performed for 90 s after 5 min adaptation to the dark. Participants were examined using white light flashes (stimulation ON time, 200 ms; stimulation OFF time, 3300 ms; total luminance, 100 cd/m^2; total intensity, 20 lux) and the average response to the light flashes was quantified. Resting diameter, amplitude, latency, duration, and velocity of pupil contraction, and latency, duration, and velocity of pupil dilation were subsequently recorded (Fig.). To minimize effects from diurnal changes, all pupillary measurements were performed within the same time period (between 8:00 AM and 9:00 AM) and under the same environmental conditions. Images with poor quality, artifacts, or eye movements not matching the central fixation axis of the optical system were excluded from the study. Measurements were performed on the day of operation (preoperative), postoperative day 1, and postoperative day 7. A single experienced grader (E.M.S.) reviewed the static and dynamic pupillometry parameters.

Statistical Analysis. Statistical analysis was performed using SPSS Statistics for Windows v24.0 (IBM Corp., Armonk, NY). Descriptive statistics were presented as the mean ± SD. The distribution pattern of



Static and dynamic pupillometry measurements obtained from a MonPackONE automatic quantitative pupillometry system.

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TABLE 1. Comparisons of Scheimpflug corneal topography parameters

	Preoperative, Mean ± SD (min–max) (n = 32)	Postoperative day 1, Mean ± SD (min–max) (n = 32)	Postoperative day 7, Mean ± SD (min–max) (n = 32)	*p*
Anterior chamber volume, mm^3	136.9 ± 34.2 (86.0–212.0)	143.8 ± 30.3 (87.0–207.0)	138.2 ± 34.2 (91.0–211.0)	0.131*
Anterior chamber depth, mm	3.0 ± 0.7 (2.2–4.7)	3.1 ± 0.6 (2.2–4.5)	3.0 ± 0.8 (1.7–4.8)	0.779*
Anterior chamber angle, degree	36.0 ± 8.7 (24.2–50.7)	38.4 ± 6.7 (27.4–52.6)	36.1 ± 8.6 (19.9–49.8)	0.647*

*Repeated Measures ANOVA test.

the variables was interpreted using visual (histogram and probability graphs) and analytical (Kolmogorov–Smirnov and Shapiro–Wilk tests) methods. A repeated measures analysis of variance (ANOVA) was used to detect significant differences between the measurements (preoperative, postoperative day 1, and postoperative day 7). The Mauchly test was used to assess the homogeneity of the variance (sphericity) within all possible pairs before calculating significance. For insignificant differences by the Mauchly test ($p \geq 0.05$), the p value was determined by the sphericity assumed test. When the Mauchly test indicated significance ($p < 0.05$), the p value was calculated using the Greenhouse–Geisser method. Multiple paired t-tests *with a Bonferroni correction were used for binary comparisons.* Statistical significance was assessed as $p < 0.05$.

RESULTS

This study included 32 eyes from 20 subjects (14 females and 6 males) ranging from 49 to 73 years of age, with a mean age of 60.0 ± 8.9. The parameters recorded from Scheimpflug corneal topography indicated no significant differences in AC volume, ACD, and AC angle ($p = 0.131$, $p = 0.779$, and $p = 0.647$, respectively) (Table 1).

The static and dynamic pupillary characteristics were described in Table 2. The amplitude of pupil contraction, scotopic PD, mesopic PD, and resting PD were significantly lower in the preoperative measurement than the postoperative day 1 measurement ($p < 0.05$). There were also significant differences in the scotopic and resting PD between postoperative day 1 and day 7 measurements ($p = 0.001$ and $p = 0.041$, respectively). In contrast, low and high photopic PD static pupillometry measurements showed no significant differences nor did the dynamic pupillometry measurements, including latency, duration, and velocity of pupil contraction and dilation values.

DISCUSSION

Blepharoplasty is one of the most common aesthetic procedures. While minor complications are rare and largely treatable, major complications, such as ACG, can result in vision loss. Postoperative complications can be divided by time of onset: early (within 1 week), intermediate (1–6 weeks), and late (>6 weeks).[8] Early postoperative complications, such as globe perforation, retrobulbar hemorrhage, ischemic optic neuropathy, and ACG, are the most serious and can cause permanent vision loss.[4,9–12] Previous studies have reported the development of PAC following blepharoplasty under local anesthesia.[3,4,13] Hueston and Heinze[14] described a postoperative retinal artery occlusion due to increased IOP, and Wride and Sanders[4] documented the loss of light perception due to acute ACG following a lower eyelid blepharoplasty. To prevent blepharoplasty-associated vision loss, early diagnosis and management of ACG are needed.

Acute PAC is characterized by an insufficient flow of aqueous humor due to blockage of the trabecular meshwork.[2]

TABLE 2. Comparisons of static and dynamic pupillometry measurements

	Preoperative, Mean ± SD (min–max) (n = 32)	Postoperative day 1, Mean ± SD (min–max) (n = 32)	Postoperative day 7, Mean ± SD (min–max) (n = 32)	*P*
Scotopic PD, mm	4.7 ± 0.9 (2.2–6.0)	4.9 ± 0.7 (3.1–5.9)	4.8 ± 0.8 (2.3–6.2)	**0.007*, 0.008†, 0.001‡**
Mesopic PD, mm	3.5 ± 0.7 (2.0–4.9)	3.9 ± 0.7 (2.7–5.7)	3.8 ± 0.7 (2.1–5.6)	**0.001*, <0.001†**
Low photopic PD, mm	2.9 ± 0.4 (1.9–3.8)	2.9 ± 0.2 (2.5–3.2)	3.0 ± 0.4 (1.8–4.2)	0.211*
High photopic PD, mm	2.5 ± 0.3 (1.6–3.0)	2.6 ± 0.2 (2.3–3.4)	2.6 ± 0.3 (1.6–3.0)	0.434*
Resting diameter, mm	4.3 ± 0.4 (3.5–5.4)	4.5 ± 0.3 (4.1–5.4)	4.4 ± 0.4 (3.4–5.6)	**0.004*, 0.006†, 0.041‡**
Amplitude of pupil contraction, mm	1.3 ± 0.3 (0.5–1.7)	1.5 ± 0.2 (0.8–1.8)	1.4 ± 0.3 (0.6–1.7)	**0.012*, 0.033†**
Latency of pupil contraction, ms	294.2 ± 33.6 (226.0–358.0)	271.6 ± 46.3 (154.0–341.0)	296.0 ± 29.8 (230.0–346.0)	0.148*
Duration of pupil contraction, ms	627.3 ± 112.6 (464.0–931.0)	601.8 ± 78.2 (457.0–776.0)	595.2 ± 71.5 (430.0–736.0)	0.940*
Velocity of pupil contraction, mm/s	4.5 ± 1.1 (1.9–6.0)	4.7 ± 1.1 (2.4–6.0)	4.6 ± 0.8 (2.7–6.1)	0.245*
Latency of pupil dilation, ms	910.4 ± 105.2 (740.0–1268.0)	873.5 ± 64.4 (737.0–1004.0)	891.5 ± 68.4 (760.0–1000.0)	0.136*
Duration of pupil dilation, ms	1572.1 ± 108.7 (1232.0–1729.0)	1604.3 ± 86.9 (1403.0–1763.0)	1573.3 ± 58.4 (1465.0–1694.0)	0.070*
Velocity of pupil dilation, mm/s	1.3 ± 0.3 (0.7–1.9)	1.4 ± 0.3 (0.7–1.8)	1.3 ± 0.3 (0.8–1.8)	0.416*

Bold values indicate statistically significant.
PD, pupil diameter.
*Repeated Measures ANOVA test.
†Significance between the preoperative and postoperative day 1 measurements (paired t-test) (pairwise comparison).
‡Significance between the postoperative day 1 and postoperative day 7 measurements (paired t-test) (pairwise comparison).

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Abnormal composition of the anterior segment and pressure imbalances between the anterior and posterior chambers of the eye can cause appositional occlusion of the trabecular meshwork by the peripheral iris.[15] Several risk factors contribute to the development of PAC, including age, sex, ethnicity, shallow AC, anteriorly positioned lens, and short axial length.[15] Additionally, pharmacologically or dark-induced mydriasis can lead to increased iridotrabecular contact, resulting in AC angle obstruction.[16] While subconjunctival and intraocular adrenaline have well-known mydriatic effects,[17,18] Rayatt and Khanna[7] have also described temporary unilateral mydriasis caused by local lidocaine and adrenaline injection into the eyelid. In addition to adrenaline, surgical factors, such as emotional stress during surgery and eye closure after surgery, may induce mydriasis.[19]

In this study, the authors measured postoperative AC and pupillary changes in patients who underwent upper eyelid blepharoplasty. The authors identified significant differences between preoperative and postoperative measurements of scotopic, mesopic, and resting PD. Lower mesopic PD values were observed preoperatively as compared to 1 day postsurgery. The postoperative day 1 values for scotopic and resting PD were higher than either preoperative or postoperative day 7 values. These results show enlarged PD within the first 24 hour following blepharoplasty, particularly under dim-light conditions. Similarities between preoperative and postoperative day 7 measurements suggest that pupil dilation decreased but returned to normal within the first week after surgery. While the factor (anxiety, pain, and/or pharmacological) responsible for pupil dilation is unknown, this study conclusively demonstrated increased PD following blepharoplasty, which has been reported to be a major PAC risk factor after oculoplastic surgeries.[3,19,20] The amplitude of pupil contraction in dynamic pupillary measurements increased 1 day after surgery compared to preoperatively, which the authors believe could be associated with increased postoperative PD.[21] Despite pupillary changes in the postoperative period, none of the participants showed signs of angle closure, including narrow-angle, shallow AC, ocular pain, photophobia, corneal edema, IOP elevation, and nonreactive mid-dilated pupil.

In contrast to pupil changes, AC parameters, including ACD, AC volume, and AC angle, did not significantly change. However, changes in iris thickness, ACD, and AC volume were observed in a study by Guo et al.[22] on healthy participants after pharmacologic mydriasis. It is possible that the pharmacological doses used during the upper eyelid blepharoplasties in the study were insufficient to affect AC changes.

The majority of patients referred to oculoplastic clinics have potential risk factors for PAC, including sex (female) and advanced age.[23] Therefore, a detailed preoperative examination of the patients, including slit-lamp biomicroscopy, IOP measurements, and angle investigation, and detailed history (e.g., intermittent eye pain, family history, drug use, and anxiety) are essential to preventing the development of blepharoplasty-associated PAC. Furthermore, examining the AC angle and ACD using imaging techniques, such as anterior segment optical coherence tomography, ultrasound biomicroscopy, and Scheimpflug corneal topography, may be useful for predicting complications. Although the frequency of angle closure following periorbital facial procedures is low, preoperative prophylactic laser iridotomy and strict postoperative control should be recommended, particularly for patients at risk of angle closure. High preoperative anxiety can increase the pain experienced by patients during and after surgery, which can exacerbate pupillary dilation.[24] Therefore, anxiolytic treatments are recommended for anxious patients before eyelid surgery. Additionally, patients should be warned to avoid dim light in the postoperative period to prevent angle closure.

To the best of the authors' knowledge, this is the first study to investigate pupil and AC changes quantitatively and objectively following blepharoplasty. This study also benefits from its design of patient recruitment. However, several limitations should be highlighted, including the limited number of participants and the lack of contact examinations, such as gonioscopy, to measure AC angles. Additionally, AC examinations using anterior segment optical coherence tomography and ultrasound biomicroscopy could improve the interpretation of the authors' findings.

This study revealed that static and dynamic pupil parameters changed following blepharoplasty, although AC characteristics were unaffected by the surgery. The authors' results indicated that low-light conditions contributed to postoperative increased PD. Therefore, it is recommended that patients with angle-closure risk factors be closely monitored and avoid low-light environments in the postoperative period.

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