Lateral canthal dynamics, correlation with periorbital anthropometric measurements, and effect of age and sleep preference side on eyelid metrics and lateral canthal tendon

Ü. BEDEN[1], M. YALAZ[2], İ. GÜNGÖR[1], Y. SÜLLÜ[1], D. ERKAN[1]

[1]Ondokuz Mayıs University Department of Ophthalmology, Samsun
[2]Çukurova University Department of Ophthalmology, Adana - Turkey

PURPOSE. *To evaluate dynamic and static properties of lateral canthal tendon and involutional periorbital anthropometric and lateral canthal changes with any possible effect of sleep preference side on these changes.*

METHODS. *Ninety-two healthy adult subjects with a mean age of 43.5 years were enrolled in the study. Lateral canthal tendon lengths (LCT), canthal movement amplitudes, and other periorbital anthropometric parameters were measured. Any effects of age and sleep preference side on anthropometric and particularly lateral canthal tendon measurements were evaluated. Pearson correlation analysis, one-way analysis of variance, and t-test for paired samples were used for statistical evaluation.*

RESULTS. *LCT length was weakly correlated with age, lower lid tractability, horizontal palpebral fissure length, and interpupillary distance and also inversely correlated with margin reflex distance, but not with other measurements. Age was also correlated with lower lid tractability, and with the ratio of LCT to the horizontal palpebral fissure length (LCT/HPFL). No correlation between age and horizontal palpebral fissure length was detected. Age was weakly and inversely correlated with canthal height but not with canthal movement amplitudes. No effect of sleep preference side on LCT length, canthal height, or lower lid tractability was detected.*

CONCLUSIONS. *Lateral canthus has a dynamic structure that is not correlated with any other periorbital anthropometric measurements. LCT length is correlated with lower lid tractability, and increases with age, unlike horizontal palpebral fissure that stays constant with increasing LCT/HPFL ratio. Sleep preference side has no effect on the eyelid metrics and LCT. (Eur J Ophthalmol 2007; 17: 143-50)*

KEY WORDS. *Aging, Eyelid metrics, Lateral canthal tendon, Sleep preference side*

Accepted: September 11, 2006

INTRODUCTION

Lateral canthal tendon (LCT) is one of the most important structures for eyelid dynamics and cosmesis. Its functions are to maintain horizontal lid stability, to convert circular contraction of orbicularis into vertical eyelid closing vector, and to be a site for attachment of anatomic structures like Lockwood ligament, lateral horn of the levator aponeurosis, lateral check ligament, and preseptal orbicularis muscle (1, 2). All these functions are maintained by static stability of LCT. In addition to its static significance, it also has

This study was presented at the 23rd ESOPRS meeting; September 15–17, 2005; Crete, Greece

1120-6721/143-08$15.00/0

a dynamic property. Its movement with globe adduction and abduction may serve in globe protection, preservation of lateral visual field, and, perhaps more importantly, nonverbal communication.

Aging causes degenerative changes in eyelids as in all tissues, and lower eyelid laxity is a well-known reason for involutional eyelid malpositions (3, 4). A probable progressive laxity of the eyelids is suspected to cause decreased horizontal palpebral fissure length and increased LCT length with advancing age (5), both of which are thought to be affected by sleep preference side and hand dominance (6). Although there are a few reports about involutional periocular anthropometric changes (7), almost none discuss changes in LCT length and dynamics with advancing age.

In this study, we wanted to evaluate the dynamic property of LCT, and to explore whether a correlation exists between canthal parameters (like movement amplitude, LCT length, and canthal height [relative to the medial canthus]) and periorbital anthropometric measurements. Evaluation of involutional periorbital anthropometric and lateral canthal changes and any possible effect of sleep preference side on these changes were further subjects of the study.

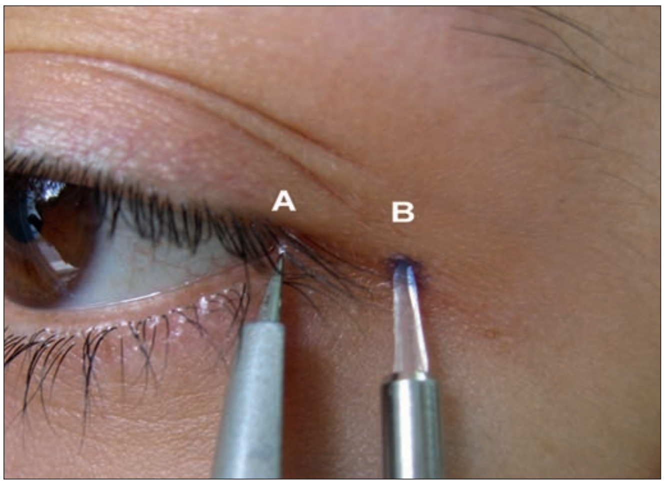

Fig. 1 - *Measurement of length of lateral canthal tendon (***A***: lateral commissure,* **B***: marked point on inner side of lateral orbital rim).*

METHODS

The study was a nonrandomized, cross-sectional study. Ninety-two normal healthy adult subjects, chosen from among the healthy relatives of patients applying to the ophthalmology department, were enrolled in the study. Fifty-five of the subjects were male and 37 were female. Mean age was 43.5±12.4 years (23–76 years). Exclusion criteria were history of any ophthalmic disease, surgery, contact lens wear, facial paralysis, thyroid eye disease, diabetes, orbital trauma and adnexal infections requiring systemic antibiotic treatment, and current pregnancy.

LCT length was measured from anterolateral view as the distance between lateral orbital rim and lateral canthal commissure in primary position of gaze while the patient was fixating to a target approximately at a distance of 5 meters. A caliper was used for measurements. The inner side of the lateral orbital rim was marked with a pen before measurement, and one leg of the caliper was rested on the rim via the marked point (Fig. 1). Canthal movement was then measured by change in canthal position on horizontal plane through anterolateral view during extreme adduction and abduction. It was measured by keeping the ruler tangential to the globe since canthus moves with the surface of the globe (Fig. 2).

Canthal height was measured as height of lateral canthus relative to horizontal plane passing through both medial canthi (Fig. 3). Negative measurements were possible, indicating lower position of lateral canthus

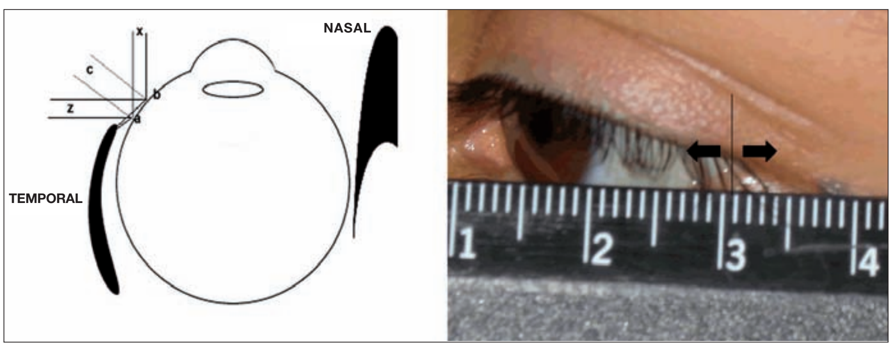

Fig. 2 - (Left) *Demonstration of movement of lateral canthus on axial plane (a: canthal position in extreme abduction, b: canthal position in extreme adduction; a-b distance indicates the distance of canthal movement. x shows excursion of lateral commissure on X-axis, z shows excursion on Z-axis, and c shows actual canthal movement amplitude measured in our study).* **(Right)** *Measurement of movement (arrows) of lateral canthus over the ruler (vertical line: natural position of lateral commissure in primary position, arrows: movement of lateral commissure with abduction and adduction).*

than medial one. Canthus–corneal apex distance (C–CO) was measured by profile view as the distance between corneal apex and lateral canthal commissure. Horizontal and vertical palpebral fissure length (HPFL and VPFL), intercanthal distance (ICD, the distance between both medial canthi), interpupillary distance (IPD), margin–reflex distance of the upper eyelid (MRD1), and lower lid tractability (LLT) were also measured in primary position for each eye as described before (8). All the measurements were taken bilaterally, and carried out by the same author (U.B.).

Subjects were asked to state their sleep preference side and were grouped into right-side sleepers (Group 1: 41 subjects), left-side sleepers (Group 2: 25 subjects), and those who did not have a preference (Group 3: 26 subjects), in order to test the effect of sleep preference side on anthropometric measurements.

Pearson correlation coefficients were calculated to characterize the linear relationship of anthropometric and subject characteristics with LCT length, and any difference of right and left sides' measurements was also tested by *t*-test for paired samples. Any detected correlation was graded as weak, modest, and strong when the determination coefficient (r^2) was 0 to 0.40, 0.40 to 0.60, and 0.60 to 1, respectively. Determination coefficients (r^2) instead of significance coefficients (p value) were preferred to grade the correlation since it was highly probable to have low p values in any study with such a sample size. LCT length/HPFL ratio was calculated for mean values of both eyes in each subject, and correlation of this ratio with age was evaluated in order to assess whether the proportion of LCT to HPFL changes with age, and direct correlation of LCT length with HPFL was also evaluated.

Differences in anthropometric parameters were tested by one-way analysis of variance (ANOVA) and then by Tukey multiple comparison tests in order to compare Groups 1, 2, and 3 for intersubject variations related to sleep preference side. In addition, *t*-test for paired samples was performed in groups in terms of intereye variations in order to determine any possible effect of sleep preference side on the measurements. Hence, LCT length, canthal height, and other parameters on the side of sleep preference were compared to the opposite side of sleep preference in the patients. Any p value of less than 0.05 was accepted as significant.

RESULTS

The mean values and standard deviations of measured parameters are given in Table I.

The mean LCT length was 7.41 and 7.57 mm for right and left sides, respectively. It was strongly correlated on both sides (r: 0.855, $p<0.001$). LCT length was weakly correlated with LLT, HPFL, and IPD and inversely correlated with MRD1. Correlation regression values, determination coefficients, and significance coefficients concerning LCT length and correlated parameters for both eyes are given in Table II. LCT length, on the other hand, was not found to be correlated

Fig. 3 - *Measurement of canthal heights (vertical arrows).*

TABLE I - MEAN VALUES ± STANDARD DEVIATIONS OF MEASURED PARAMETERS (in mm)

	Right	Left
No. (male/female)	92 (55/37)	
LCT length	7.41±1.29	7.57±1.29
Canthal movement	3.34±0.95	3.31±0.85
LLT	10.51±2.21	10.28±2.24
MRD1	3.38±0.87	3.38±0.87
Canthal height	1.54±1.11	1.55±1.17
C-CO distance	12.04±1.20	12.07±1.22
HPFL	28.98±1.69	28.82±1.68
VPFL	9.61±1.15	9.70±1.14
ICD	32.1±2.52	
IPD	60.83±3.22	

LCT = Lateral canthal tendon; LLT = Lower lid tractability; MRD1 = Margin reflex distance of the upper eyelid; C-CO Distance = Canthus-cornea distance from profile view; HPFL = Horizontal palpebral fissure length; VPFL = Vertical palpebral fissure length; ICD = Intercanthal distance; IPD = Interpupillary distance

TABLE II - CORRELATION REGRESSION VALUES (r), DETERMINATION COEFFICIENTS (r^2), AND SIGNIFICANCE COEFFICIENTS (p) FOR BOTH EYES CONCERNING LCT AND CORRELATED PARAMETERS

LCT length	LLT	HPFL	IPD	MRD1
Right	r=0.348 r^2=0.121 p=0.001	r=0.216 r^2=0.047 p=0.038	r=0.207 r^2=0.043 p=0.048	r=-0.333 r^2=0.111 p=0.001
Left	r=0.279 r^2=0.078 p=0.007	r=0.240 r^2=0.058 p=0.021	r=0.231 r^2=0.053 p=0.027	r=-0.262 r^2=0.069 p=0.012

LCT = Lateral canthal tendon; LLT = Lower lid tractability; HPFL = Horizontal palpebral fissure length; IPD = Interpupillary distance; MRD1 = Margin reflex distance of the upper eyelid

with canthal height, movement amplitude, ICD, VPFL, and C-CO distances on either side.

LCT length was found to be weakly correlated with age (r=0.386, p<0.001 for right side; r=0.290, p=0.005 for left side). Scatter plots of LCT lengths according to age are given in Figure 4. When subjects were subgrouped according to sleep preference side, one-way ANOVA did not reveal any significant difference among groups regarding LCT length or other eyelid metrics (p>0.05). In addition, correlations between age and LCT length were not different for both sides in right or left side sleepers, indicating that involutional changes were not affected by sleep preference side. Moreover, *t*-test for paired samples revealed no difference regarding eyelid metrics and lateral canthal tendon in right and left sides in Groups 1, 2, and 3.

Mean lateral canthal movement amplitudes were 3.34 mm and 3.31 mm for right and left sides, which were highly correlated with each other (r=0.772, p<0.001). However, they were not found to be correlated with any other parameters. They were found to be inversely but insignificantly correlated with age.

Mean lateral canthal height was 1.54 and 1.55 mm for right and left eyes, respectively. Canthal heights were also strongly correlated with each other (r: 0.994), and weakly correlated with MRD1 on right (r=0.374, p<0.001) and left (r=305, p=0.03) sides, and VFPL on right (r=0.274, p=0.008) and left (r=0.250, p=0.016) sides. Canthal height was not found to be correlated with LLT, C-CO distance, ICD, HPFL, and IPD as well as LCT length, and canthal movement amplitudes as stated before. At the same time, a significant weak inverse correlation was present between canthal height and age (r=–0.215, p=0.40 for right side; r =–0.257, p=0.014 for left side). Scatter plots of lateral canthal heights according to age are given in Figure 5. Canthal height was not found to be sensitive to sleep preference side since no difference was detected among the three groups regarding canthal heights according to one-way ANOVA.

Lower lid tractability amplitudes, which had a mean value of 10.51 and 10.58 mm for right and left sides, were strongly correlated with each other (r: 0.919), but not with any other parameters except LCT length, as stated above. There was a significant weak positive correlation between lower lid tractability and age. Correlation coefficient for right eyes was 0.357, which was significant to the 0.001 level, and for left eyes it was 0.320, which was significant to the 0.02 level. Scatter plots of LLT amounts according to age are given in Figure 6. This correlation was not found to be affected by sleep preference side, since it was not different in subgroups1, 2, and 3.

Horizontal and vertical palpebral fissure lengths as well as MRD1 were inversely but insignificantly correlated with age, but the LCT/HPFL ratio was found to increase with age (r=0.407, p<0.001). In spite of this, not an inverse but a linear correlation was detected between LCT length and HPFL on both sides (r=0.216, p=0.04 for right eyes; r=0.240, p=0.02 for left eyes).

No significant differences of mean values or new correlations regarding all parameters were detected in subgroups according to sleep preference side (Groups 1, 2, and 3).

DISCUSSION

LCT is one of the most important structures for any surgeon interested in oculoplastic surgery. Static and dynamic properties of LCT provide the most essential factors of eyelid cosmetics and functions (1, 9-15). Many studies have been performed about static properties of LCT, but its dynamic properties have not been extensively investigated (16-18).

In our study, we could not find any significant correlation between canthal movement and other parameters. This might imply that the dynamic property of lateral commissure is not dependent on any other eyelid metrics, with functional importance still remaining to be explored. It is also possible that we were not able to reliably measure movement across subjects without using complicated software. This might be the case even though we had a good inter-eye correlation of movement measurements, since inter-eye measurements reflect within subject variation and intersubject measurements reflect a different type of variation.

Cook et al (17) reported that lateral canthus moves in opposite direction with the globe when looked at from the anterior view, unlike from the profile view, and proposed that canthal movement is more important in globe protection than in maintaining a lateral visual field. This was not correlated with our results since we detected posterolateral movement of canthus during abduction, and anteromedial movement during adduction. The difference might be due to differences in measurement techniques of the two studies. Cook et al (17) calculated lateral canthal movement as the difference in measurement of horizontal distance of lateral canthus to medially placed vertical line during abduction and adduction. This indirect calculation may result in false measurements. As seen in Figure 2, measurements from anterior view detect only excursion of lateral commissure on X-axis, which is clearly seen to be less than actual movement amplitude on surface of the globe. Nor is it correct to measure it by profile view as seen in Figure 2, since this time it would

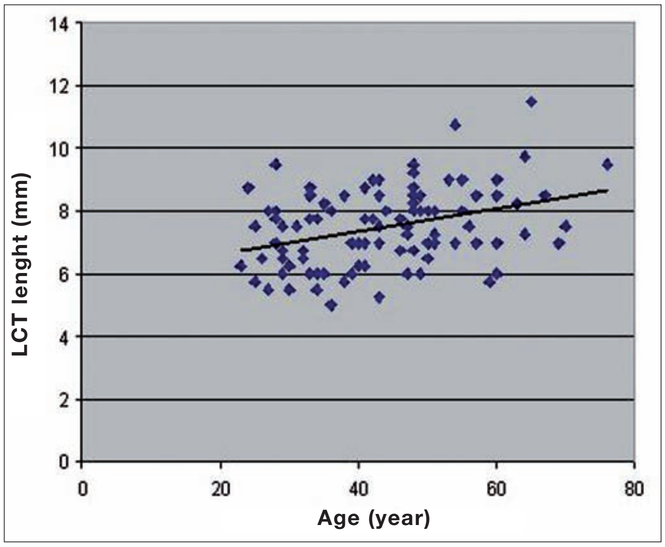

Fig. 4 - *Scatter plot of lateral canthal lengths according to age and regression line.*

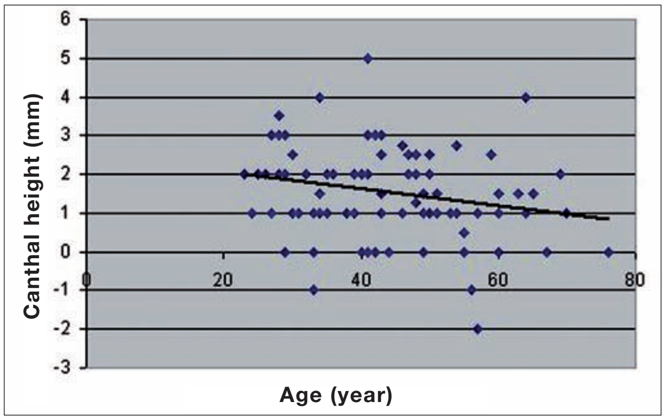

Fig. 5 - *Scatter plot of lateral canthal heights according to age and regression line.*

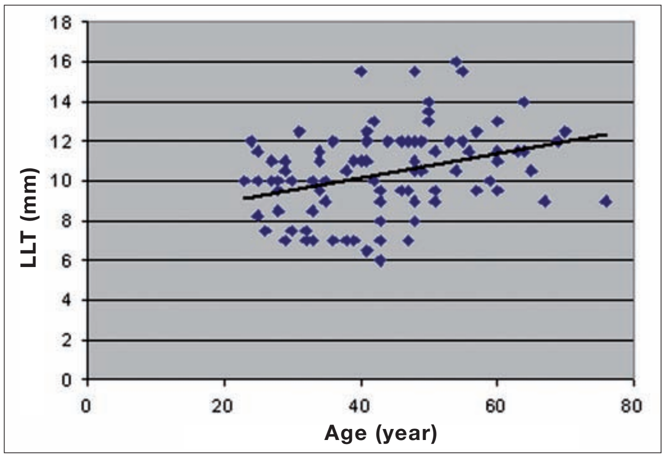

Fig. 6 - *Scatter plot of lower lid tractability amounts according to age and regression line.*

reflect commissural movement on Z-axis, which is shorter than actual movement amplitude. In addition, real canthal movement might be generated by fibromembranous slip from lateral rectus muscle, hence it is directed posteriorly (on Z-axis) (16, 18). Thus, active movement implies a posterolateral retraction while anteromedial movement implies return to the resting position of lateral commissure. Any movement on X-axis, however, must be due to effect of orbicularis and globe shape. When largest diameter of globe (equator) rests on lateral canthus (like in adduction) it is logical to have it displaced more laterally and it may give a false impression that the lateral canthus moves laterally during globe adduction or vice versa. In our study, direct excursion of lateral commissure on a plastic ruler was measured (Fig. 2), and this may give rise to less erroneous readings. Gioia et al (16) also measured lateral canthal movement in anterolateral view (as we did) and detected that lateral canthus moves laterally about 2 mm in lateral gaze. This seems to be more consistent with our results, since we measured about 3.30 mm of lateral displacement of lateral canthus in lateral gaze.

The most accurate way of measuring lateral canthal movement (without using imaging or software techniques) is by measuring it from anterolateral view tangential to the globe (Fig. 2). The most correct way to measure a two-dimensional motion around a circle (or globe) in one dimension is to measure it at the center of the motion range and perpendicular to radius (Fig. 2). Clinical measurements are always of practical value even though it is difficult for any contemporary ophthalmologist to resist the use of sophisticated computerized and imaging methods.

In spite of controversial results, lateral commissure seems to have a dynamic status, and this should be kept in mind during planning of eyelid shortening procedures. Fagien (6) has abandoned horizontal eyelid shortening procedures via lateral tarsal strip procedure since it replaces the dynamic flexible LCT with an inflexible fixation of lateral tarsus to orbital periosteum. At the same time, one should not forget that movement of lateral canthus is generated by a slip from lateral rectus muscle via the deep head of LCT (18), which might not be disturbed by lateral tarsal strip procedure. Any effect of lateral tarsal strip procedure on lateral canthal dynamics is the subject of another study, which may clarify the need to reconsider our algorithms in choosing such procedures.

LLT was also weakly correlated with LCT but not with any other parameters. This may show a direct relation of lower lid elasticity to LCT, but not to horizontal or vertical palpebral fissure lengths. This suggests that tarsi forming horizontal eyelid configuration are more solid and inelastic structures than LCT and they provide skeleton of eyelids, the length of which has no effect on lower lid elasticity, while LCT is more important in providing an elastic property for horizontal and vertical eyelid motions.

Typically medial and lateral canthal tendons become lax or attenuated with an inferior canthal descent as aging progresses. Descent of the lateral canthal tendon has been blamed for the shortening of HPFL (3-5), but there are controversial reports concerning involutional changes in HPFL. Studies have reported a smaller HPFL in people over 50 years of age, which was confirmed by van den Bosch et al (19), who has reported a 10% decrease in HPFL after 45 years of age. However, Liu et al (20) have found no difference in size of the lower eyelid between subjects younger and older than 50 years of age. In our study, we detected an inverse but insignificant correlation between HPFL and age.

Van den Bosch et al (19) measured HPFL as reflection of palpebral fissure on X-axis on photographs, and detected 10% decrease in HPFL after 45 years of age in 280 adult subjects. Methodologic differences in measurement techniques may explain the difference between measured HPFL lengths in our study and that of van den Bosch et al. They also proposed that shortening of HPFL from the age of 45 years was likely due to progressive laxity of the medial and lateral canthal structures, which is consistent with the results of our study, since we detected a significant positive linear correlation between age and LCT.

This is an important finding, since one may expect that an involutional increase in LCT length should cause a decrease in HPFL. But we were unable to detect a significant decrease in HPFL with aging. It was also interesting to see a positive correlation between LCT length and HPFL since one can expect vice versa, but should LCT length and HPFL be linearly correlated in normal subjects, this would mask any inverse correlation of involutional changes in dimensions of these two. Thus, we would possibly be unable to detect that inverse correlation by only comparing LCT length and

HPFL. In order to assess this relation, we calculated LCT length/HPFL ratio for each patient (to preclude any possible linear correlation already existing in normal subjects) and we detected a positive correlation of this ratio with age. This showed that LCT length/HPFL ratio increases as one gets older. These findings may imply that, in spite of a relatively constant HPFL, LCT length increases with LCT length/HPFL ratio. Having a relatively constant HPFL in spite of increasing LCT length may be due to pressure of the globe itself, which normally converts linear HPFL into a two-dimensional circular configuration or by some other unexplained mechanism.

Fagien et al (6) proposed that an increased LCT length with advancing ages may be affected by sleep preference side and hand dominance. We compared LCT lengths in both right- and left-side sleepers, and no statistically significant difference could be detected. Nor did the detected correlations of LCT length with age change in groups of right- and left-side sleepers. Thus, sleep preference side does not seem to be important in involutional increase in LCT length and it does not seem to affect LCT length's correlation with age.

In conclusion, LCT length increases with age, but horizontal palpebral fissure rather stays constant with increasing LCT/HPFL ratio. Aging also causes a canthal descent, and increased LLT. These findings should be better tested in further studies with a greater number of subjects or by following a group of patients over time. Sleep preference side, in contrast, does not seem to have any effect on these involutional changes. Lateral canthus has a dynamic structure, and it may have functional roles during globe movements since it is not correlated with any other eyelid metrics. More importantly, LCT contributes to lower lid elasticity, unlike horizontal eyelid structures (tarsal plates), which should be kept in mind during planning of eyelid shortening procedures. Further studies concerning eyelid malpositions and LCT are advocated.

ACKNOWLEDGEMENTS

Statistical consultation and assistance was provided by Prof. Dr. Yuksel Bek, Ondokuz Mayıs University, Faculty of Medicine, Department of Biostatistics, Samsun, Turkey.

None of the authors has any financial interest in this article.

Reprint requests to:
Ümit Beden, MD
Ondokuz Mayıs University
Department of Ophthalmology
Kurupelit
55139 Samsun, Turkey
umite@yahoo.com

REFERENCES

1. McCord CD, Boswell CB, Hester TR. Lateral canthal anchoring. Plast Reconstructr Surg 2003; 112: 222-36.
2. Bedrossian EH. Surgical anatomy of the eyelids. In: Della Rocca DC, Bedrossian HE, Arthurs BP, eds. Ophthalmic Plastic Surgery. Decision Making and Techniques. London: McGraw-Hill, 2002; 23-43.
3. Spinelli HM. The midface and lateral canthus. In: Spinelli HM, ed. Atlas of Aesthetic Eyelid and Periocular Surgery. 1st ed. Philadelphia: Elsevier, 2004; 120-35.
4. Tyers AG, Collin JRO. Anatomy. In: Tyers AG, Collin JRO, eds. Colour Atlas of Ophthalmic Plastic Surgery, 2nd edition. Oxford: Butterworth-Heinemann, 2001; 1-18.
5. Gigantelli JW. Entropion. In: Yanoff M, Duker JS, eds. Ophthalmology. Second edition. Philadelphia: Mosby, 2004; 668-75.
6. Fagien S. Commentary on "The horizontal dynamic of the medial and lateral canthus". Ophthal Plast Reconstructr Surg 2003; 19: 303-4.
7. Yaremchuk MJ. Restoring palpebral fissure shape after previous lower blepharoplasty. Plast Reconstructr Surg 2003; 111: 441-50.
8. Tyers AG, Collin JRO. Preoperative evaluation. In: Tyers AG, Collin JRO, eds. Colour Atlas of Ophthalmic Plastic Surgery. 2nd ed. Oxford: Butterworth Heinemann, 2001; 49-58.
9. Hesse RJ. The tarsal sandwich: a new technique in lateral canthoplasty. Ophthal Plast Reconstructr Surg 2000; 16: 39-41.
10. Fagien S. Algorithm for canthoplasty: the lateral retinacular suspension: a simplified suture canthopexy. Plast Reconstructr Surg 1999; 103: 2042-58.
11. Jelks GW, Glat PM, Jelks EB, et al. The inferior reti-

nacular lateral canthoplasty: a new technique. Plast Reconstructr Surg 1997; 100: 1262-75.
12. Glat PM, Jelks GW, Jelks EB, et al. Evolution of the lateral canthoplasty: techniques and indications. Plast Reconstructr Surg 1997; 100: 1396-405.
13. Rosenstein T, Talebzadeh N, Pogrel A. Anatomy of the lateral canthal tendon. Oral Surg Oral Med Oral Pathol Endod 2000; 89: 24-8.
14. Arshad RM, Bryn CM, William PA. Surgical anatomy of the ligamentous attachments of the lower lid and lateral canthus. Plast Reconstructr Surg 2002; 110: 873-84.
15. Knize MD. The superficial lateral canthal tendon: anatomic study and clinical application to lateral canthopexy. Plast Reconstructr Surg 2002; 109: 1149-57.
16. Gioia VM, Linbrg JV, McCormic SA. The anatomy of the lateral canthal tendon. Arch Ophthalmol 1987; 105: 529-32.
17. Cook T, Goldberg RA, Douglas R, et al. The horizontal dynamic of the medial and lateral canthus. Ophthal Plast Reconstructr Surg 2003; 19: 297-303.
18. Lewis SJ, Tasker HN. Mechanism related to the lateral rectus muscle capable of retracting the outer canthus of the eye. Br J Ophthalmol 1994; 78: 799-800.
19. Van Den Bosch WA, Leenders I, Mulder P. Topographic anatomy of the eyelids and effects of sex and age. Br J Ophthalmol 1999; 83: 347-52.
20. Liu S, Stasior OG. Lower eyelid laxity and ocular symptoms. Am J Ophthalmol 1983; l95: 545-51.