Objective: To investigate the anatomophysiologic aging-related changes in the orbicularis oculi muscle.

Methods: We examined the full-thickness histologic characteristics of the upper eyelids from cadavers of 30-, 40-, 60-, and 70-year-old men and the muscle interference pattern (IP) of 68 healthy volunteers of both sexes aged 18 to 73 years.

Results: Histologic analysis revealed that in the aging upper eyelid, changes were primarily in the skin and subcutaneous layers with the characteristic loss of collagen elastic fibers; however, the whole muscle layer was histologically intact, with no signs of aging; loss of fibers, loss of adherence to surrounding structure, or ptosis. Neurophysiologic studies of the electromyographic IP of the orbicularis oculi muscle confirmed that the full efficiency of orbicularis oculi function was intact in the age group studied (18-73 years) in both sexes.

Conclusion: Our results suggest that the anatomophysiologic characteristics of the orbicularis oculi muscle remain intact through advancement of age.

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It is agreed that the aging process results in the gradual loss of elastic fibers and relaxation of skin, giving it a loose appearance,¹-³ and it is argued that the muscle ptosis may contribute to the aging look of the upper eyelid.⁴ The eyelids are perhaps the first structures in the face to be affected by aging. In the upper periorbita, there is occasionally an excess bulge of the periorbital fat (ie, the retro-orbicularis oculi fat) as a result of aging process.³ These anatomical changes result in various functional and cosmetic deformities, such as ptosis and limitation of visual fields or unsightly upper eyelid, that may require upper blepharoplasty.

Upper blepharoplasty is a surgical procedure that addresses skin laxity and retro-orbital fat bulge. A standard technique of upper blepharoplasty includes an en bloc excision of skin and orbicularis oculi.⁶⁻⁸ This muscle is divided into 2 portions: an orbital portion and a palpebral portion. The latter is limited to the eyelids, which are composed of fibers coming from the medial canthal tendon and are inserted into the external palpebral raphe. The orbital portion is inserted into the medial canthal tendon and into the orbital rim from the attachment of the medial canthal tendon to the supraorbital notch. The functions of the orbicularis oculi are therefore to close the eyelids, to compress the tears and to dilate the lacrimal sac.

In the current study, we show that the whole muscle layer remains morphologically intact, and its physiologic function remains more or less intact and is not affected by the advancement of age as assessed by interference pattern (IP) analysis. However, the aging changes are primarily in the skin and subcutaneous layer. These findings make an en bloc removal of skin and muscle undesirable. Alternatively, a split incision in the muscle layer and orbital septum will allow removal of the needed amount of fat with or without careful removal of a narrow strip of the muscle fibers.

METHODS

HISTOLOGIC STUDIES OF THE WHOLE LAYERS OF THE UPPER EYELIDS

The upper eyelids were surgically removed from 4 different cadavers of men aged 30, 40, 60, and 70 years. The samples were excised from the level of the eyebrow to the eyelashes and included all the layers of the upper eyelids. Embedded paraffin sections were then processed and stained. Photographs of the histologic slides at low- and
IP ANALYSIS

Recordings were performed using a digital Nihon Kohden Neuropack S1 EMG/EP measuring system (model MB400 K; Tokyo, Japan). Concentric needle electrodes 0.3 mm in diameter were used. The band pass was set at 20 to 10 KHz, the sweep speed was set at 100 milliseconds, and the gain was set at 1 mV per division. The patient was instructed to make muscle contractions of variable forces by shutting the eyes starting at a weaker force and ending with a full, strong contraction. Recordings were made for epochs of 20 seconds and electronically stored for off-line analysis. The needle was moved around its axis and in and out to sample high-power fields were taken by a camera attached to light microscopy.

Figure 1. A, Normal upper eyelid section of the 30-year-old male control cadaver showing intact stratified squamous epithelium and underlying collagen layer. B, Upper eyelid section of a 40-year-old male cadaver showing intact epithelium and normal underlying layers. C, Upper eyelid section of a 60-year-old male cadaver showing intact stratified squamous epithelium with marked decrease of underlying collagen with normal muscle layer. D, Upper eyelid of a 70-year-old male cadaver showing intact stratified squamous epithelium with significant decrease of underlying collagen fibers with normal muscle layer. (Hematoxylin-eosin; the upper panels in each figure part show low-power magnification [original magnification × 100]; bottom panels in each figure part, high-power magnification [original magnification × 400].)
different muscle sites. Twenty recordings were made for each muscle. Brief rests were allowed in between muscle contractions to avoid fatigue. The means of turns per second, amplitudes, and number of small segments (NSS) were automatically computed and displayed. Recordings were made without force monitoring.

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS statistical software for Windows (version 12; SPSS Inc, Chicago, Illinois). The descriptive data were computed to summarize the means and standard deviations for quantitative variables and percentages for qualitative variables. The $\chi^2$ test was used to assess the difference between quantitative variables, whereas the independent sample $t$ test was used for qualitative variables. Differences were considered significant at the $P<.05$ level. The correlation coefficient between the final functional grades and ages of patients was calculated.

RESULTS

HISTOLOGIC APPEARANCE OF THE UPPER EYELIDS IN DIFFERENT PERIODS OF AGE

Figure 1 shows the histologic appearance of the upper eyelids from 4 different cadavers of men aged 30, 40, 60, and 70 years. Figure 1A shows that in the 30-year-old cadaver there was minimal elastic tissue loss or skin laxity. Therefore, this sample represents the control that can be compared with the samples from the other 3 cadavers (Figure 1B-D), which showed marked reduction in the elastic collagen layer but with no change in the muscle fibers’ bulk with advanced age.

IP ANALYSIS AND CORRELATION WITH AGE

The population sample is formed of 68 healthy volunteers, 31 men (45%) and 37 women (55%). Their ages ranged from 18 to 73 years. The men ranged in age from 18 to 66 years (mean [SD] age, 46.3[14.9] years), and the women ranged in age from 19 to 73 years (40.7[13.4] years). The mean parameters of IP analysis in men and women are shown in the Table. Compared with men, women showed a significantly lower number of turns ($P=.04$). Turns, amplitude, and NSS showed no correlations with age ($P=.18$, $P=.19$, and $P=.87$, respectively), as shown in Figures 2, 3, and 4.

COMMENT

This study was performed (1) to better understand the upper periorbital anatomo-physiologic characteristics so as to give the best possible balance between cosmetic effect and the normal function of the upper eyelid and to minimize the postoperative complications, and (2) to investigate whether the orbicularis oculi contributes to the aging appearance of the upper periorbita and whether its physiologic function is affected by the advancement of age.

The usual technique of upper blepharoplasty involves a high eyelid crease incision, with either an en bloc or separate excision of skin and orbicularis oculi muscle. This technique allows direct access to the retro-orbicularis oculi fat and the levator aponeurosis for further debulking of periorbital soft tissue and supra tarsal fixation, respectively. Excessive removal of orbicularis oculi muscle may result in permanent lagopthalmos, which is a serious complication because it can lead to corneal ulcerations or may cause blindness. Moreover, unnecessary removal of orbicularis oculi muscle can alter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean (SD) [Min-Max]</th>
<th>$P$ Value</th>
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</thead>
<tbody>
<tr>
<td>Turns/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>442.92 (163.94) [15-798]</td>
<td>.04&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Women</td>
<td>367.06 (106.93) [13-520]</td>
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<tr>
<td>Amplitude</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>369.69 (69.13) [185-495]</td>
<td>.80&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Women</td>
<td>362.69 (125.96) [5-549]</td>
<td></td>
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<tr>
<td>NSS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>288.58 (175.05) [0-796]</td>
<td>.19&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Women</td>
<td>236.35 (132.16) [75-558]</td>
<td></td>
</tr>
</tbody>
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<sup>a</sup>Significant.  
<sup>b</sup>Nonsignificant.
the position of eyebrows, resulting in the long-term complication of eyebrow ptosis because the remaining functioning orbicularis muscle can directly affect eyebrow position through contraction.13

Our histologic study showed that orbicularis oculi muscle remained more or less intact and that the muscle fibers remained comparatively intact, with the same bulk of fibers through the aging process. Moreover, there were no signs of histologic muscle ptosis. However, the loss of skin elastic fibers and the skin laxity were marked and paralleled the advancement of age.

The electromyographic IP, which is the building up of single motor unit action potentials (MUAPs), provides information about the number, firing rate, and recruitment characteristics of the motor unit as well as waveforms of the recruited motor units.14 Nandedkar et al15 developed an objective quantitative method for evaluation and analysis of IP based on the turns and amplitude of the signal. The activation measures the fullness of the IP and correlates strongly with the force of muscle contraction. The NSS measures the complexity of the IP, which is a reflection of the polyphasicity of the component MUAPs.

Previous studies10,17 showed that for limb muscles there is a tendency for increased amplitude in those older than 60 years; however, other parameters of IP showed no change with age. Aging affects different muscles in different patterns. The more distal muscles are more likely to undergo such changes than proximal ones. In this study, using a correlation coefficient, age was observed to have a nonsignificant effect on any of the parameters of the IP.

In the current study, the electrophysiologic findings support the histologic findings and negate the need for excessive excision of the orbicularis oculi muscle in upper blepharoplasty. Therefore, we favor the minimally invasive surgical approach to upper blepharoplasty with muscle sparing. However, in some cases, especially in elderly patients, the protruded fat contributes considerably to the aging appearance of the upper eyelids and needs to be excised to reduce the soft tissue volume. In these cases, a split incision in the muscle layer will allow herniation of the excess fat that needs to be removed. In our experience, this approach will leave the intact muscle in situ and reduce the complications that may be encountered in muscle-cutting. An alternative approach to the bulging fat would be through orbital septorrhaphy, which may result in a more youthful appearance owing to preservation of the fat.3

In conclusion, we propose that upper blepharoplasty with muscle sparing, with or without reduction of soft tissue volume according to the patient’s need, would allow a nice balance between the aesthetic result and the normal anatomophysiological characteristics of the upper periorbita. However, if a better-defined eyelid crease is required for aesthetic reasons, then a careful removal of a narrow strip of orbicularis would suffice.

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Author Contributions: The authors all had complete access to the data presented herein and are responsible for its accuracy. Study concept and design: Pottier. Acquisition of data: Pottier and N. Z. El-Shazly. Analysis and interpretation of data: Pottier and N. Z. El-Shazly. Drafting of the manuscript: A. E. El-Shazly. Critical revision of the manuscript for important intellectual content: A. E. El-Shazly. Statistical analysis: N. Z. El-Shazly.

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