

Spatial Orientation of Motor Innervation to the Lower Orbicularis Oculi Muscle

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Background: Blepharoplasty and midface access incisions that are currently used were designed on the premise that innervation to the lower eyelid orbicularis oculi muscle approaches the muscle from its lateral aspect and that its segmental fascicles run parallel to the muscle's fibers. These incisions yield a high rate of complications that include ectropion and other eyelid malpositions.

Objective: The goal of this study was to investigate the innervation of the lower orbicularis oculi muscle and determine how it is affected by lower eyelid surgery.

Methods: Macroscopic anatomic dissections were performed on 10 frozen cadavers, and the origin and distribution of innervation was mapped. An additional 12 fresh cadaver specimens were dissected through use of 3.5× loupe magnification. Six ultrafresh cadaver specimens were used for histologic examination. Fixation was done in 10% formaldehyde. Axial incisions perpendicular to the facial plane were made at 5-mm intervals from the lower forehead level to the oral commissure. Hematoxylin and eosin specimens and Masson's trichrome specimens were made from alternating slices taken at 5-mm intervals.

Results: The results of this anatomic study suggest that the upper eyelid orbicularis oculi muscle is innervated by fascicles of the temporal branch of the facial (VII) nerve. These nerves travel along the undersurface of the muscle and branch out parallel to the muscle fibers. The lower eyelid orbicularis oculi muscle seems to be innervated by 3 to 5 branches of the zygomatic nerve, which splits into 2 large groups of fascicles as it crosses the zygomaticus major muscle. These nerves continue toward the orbicularis oculi muscle, splitting into a plexus of nerves that approaches the orbicularis oculi muscle fibers at an angle of approximately 90°. No significant branches from the lateral aspect of the lower orbicularis oculi were observed in this study.

Conclusions: The results of this anatomic study indicate that techniques that (1) approach the midface through the lower eyelid and (2) change the plane of dissection from deep to the orbicularis oculi muscle to superficial to the zygomaticus major muscle may place the innervation of the orbicularis oculi muscle at much higher risk.

The standard approach for lower blepharoplasty entails (1) an incision at the subciliary margin with extension of the incision to the crow's-feet area, (2) separation of skin from the pretarsal portion of the orbicularis oculi muscle, (3) transection of orbicularis oculi muscle fibers to enter deep into the orbital fat pad via division of the orbital septum, and (4) dissection of muscle/skin flap down to the level of the inferior orbital rim.^{1,2} Several techniques for correction of the "tear trough" deformity around the

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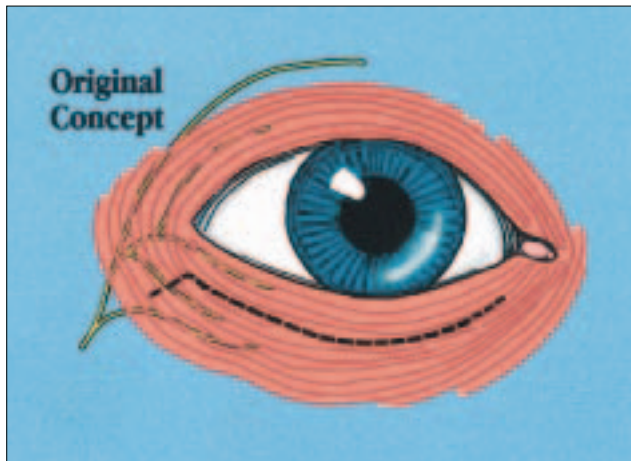


Figure 1. The traditional concept of the innervation to the lower orbicularis oculi muscle. According to this view, the nerve fascicles travel parallel to the muscle fibers.

eyes and for midface lifting at the intermuscular or subperiosteal planes use the same blepharoplasty access.³⁻⁵

These techniques are widely considered to be safe because they were conceived under the premise that innervation to the lower orbicularis oculi muscle approaches the muscle from its lateral aspect and that its segmental nerve fascicles run parallel to the orientation of the muscle fibers.^{6,7} With this understanding, one would naturally assume that the separation of the pretarsal portion of the orbicularis oculi muscle from the preseptal portion will leave the pretarsal innervation intact (Figure 1). However, these procedures are associated with a high rate of complications, among which ectropion and other eyelid malpositions are the most troublesome.⁸⁻¹⁰ Careful clinical observation of patients experiencing these complications suggested that the main cause might be denervation of the pretarsal portion of the orbicularis oculi muscle. For these reasons, we decided to investigate the innervation of this muscle and to determine how standard blepharoplasty techniques and midface operations might affect its function.

Cadaver Study

Macroscopic anatomic dissections of 10 frozen cadaver specimens were carried out. The temporal, zygomatic, and buccal nerves were dissected, and their distribution and trajectory were mapped. This initial study suggested that innervation to the lower orbicularis oculi muscle was not as conventionally described. However, the terminal branches distributing into the muscles were difficult to

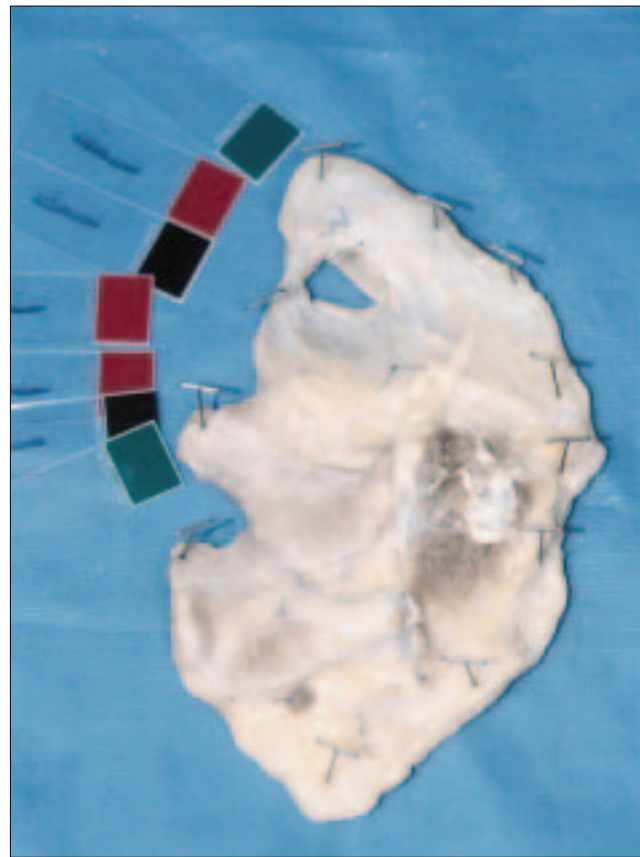


Figure 2. The specimen fixated in 10% formaldehyde for histologic examination.

visualize. We assumed that this difficulty was due to the power of magnification (naked eye) and the unavoidable lysis of preserved tissues over a period of time, particularly the fat component of nerve branches.

Twelve additional fresh cadavers (24 hemiface specimens harvested within 48 hours of death) were dissected through use of 3.5× loupe magnification. Furthermore, to avoid “specimen errors,” we used 6 ultrafresh cadaver specimens within 4 to 8 hours of death for histologic examination. The soft tissues were dissected from the facial skeleton and fixation was performed in 10% formaldehyde (Figure 2). Axial incisions perpendicular to the facial plane were made every 5 mm from the lower forehead level to the oral commissure. Hematoxylin and eosin–stained specimens and Masson’s trichrome–stained specimens were made from alternating slices taken at 5-mm intervals.

Results of Cadaver Study

The upper eyelid orbicularis oculi muscle is innervated primarily by fascicles of the intermediate and most anteri-

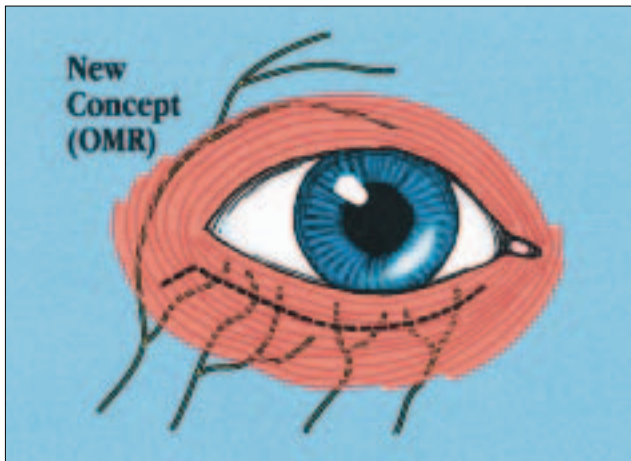


Figure 3. New concept of the innervation of the lower eyelid orbicularis. The fascicles for motor innervation travel perpendicular to the muscle fibers.

or branches of the temporal nerve. They begin splitting to dive into the upper orbicularis muscle at approximately the level of the superior border of the zygomatic arch. Occasionally (20.8% of specimens), a minor branch of the temporal nerve, barely identifiable by 3.5× loupe magnification, was seen entering the lateral aspect of the lower orbicularis oculi muscle. This branch seemed to enter the lateral orbital portion of the lower orbicularis muscle and was untraceable by histologic examination beyond the orbital portion.

The lower eyelid orbicularis oculi muscle is innervated predominantly by branches of the zygomatic nerve (Figure 3). Three to 5 dissectable branches were found entering the lower margins of the zygomaticus major muscle. These nerves usually split into 2 large groups of fascicles as they cross the underside of the zygomaticus major muscle. The lateral group, which is larger, is located approximately 10 mm from the zygomaticus major muscle origin (Figure 4). The medial group is located approximately at the midpoint of the muscle's length. This group of nerves splits into several branches, creating a plexus of nerves that dives under the zygomaticus major muscle and then under the zygomaticus minor muscle (if it exists) and the orbicularis oculi muscle (Figure 5). We have called it the *zygo-orbicular plexus* to indicate this particular distribution and the close proximity to the orbicularis oculi and zygomaticus major muscles.

This particular anatomic distribution might have embryologic and clinical significance inasmuch as the zygomaticus major muscle and orbicularis oculi muscle have the

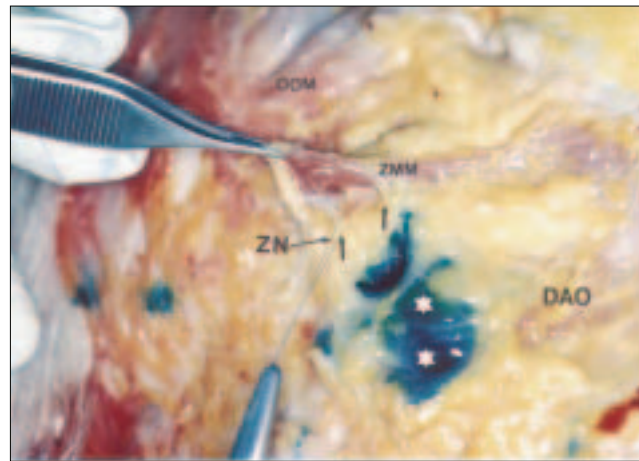


Figure 4. This anatomic preparation shows the lateral group of nerve fascicles of the zygomatic nerve traveling under the zygomaticus major muscle near the origin. The forceps is holding the origin of the zygomaticus major muscle. The stars indicate the fascia overlying the buccal fat pad; arrows indicate zygo-orbicular plexus. OOM, Orbicularis oculi muscle; ZMM, zygomaticus major muscle; ZN, zygomaticus nerve; DAO, depressor anguli oris.

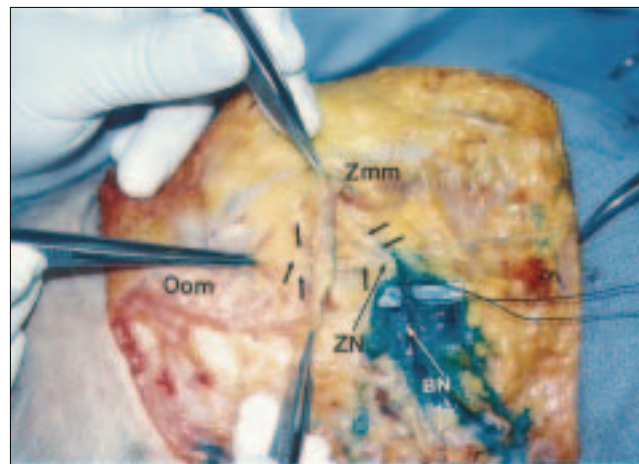


Figure 5. The zygomatic nerve giving branches to form the zygo-orbicular plexus. This plexus is distributed into 2 main groups, 1 lateral and 1 medial. Arrows point to the nerve fascicles traveling underneath the zygomaticus major muscle and branching into the deeper surface of the orbicularis oculi muscle. The apparent continuity between the buccal nerve and the zygomatic nerve is due to the artifact produced by the traction of the main trunk of the zygomaticus nerve. Oom, Orbicularis oculi muscle; Zmm, zygomaticus major muscle; ZN, zygomaticus nerve; BN, buccal nerve.

same embryonic origin. This plexus of nerves approaches the orbicularis oculi muscle fibers at an angle of approximately 90°. In 8 (33.3%) cases, a significant macroscopically dissectable branch of the zygomatic nerve was found crossing over the zygomaticus major muscle to

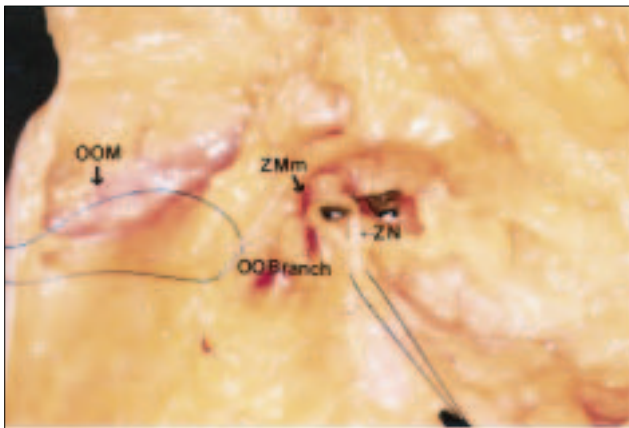


Figure 6. Anatomic preparation shows the zygomatic nerve diving under the zygomaticus major muscle. Observe the macroscopically dissectable branch from the zygomatic nerve traveling over the superficial surface of the zygomaticus major muscle. OOM, Orbicularis oculi muscle; ZMm, zygomaticus major muscle; ZN, zygomatic nerve; OOB, orbicularis oculi branch.

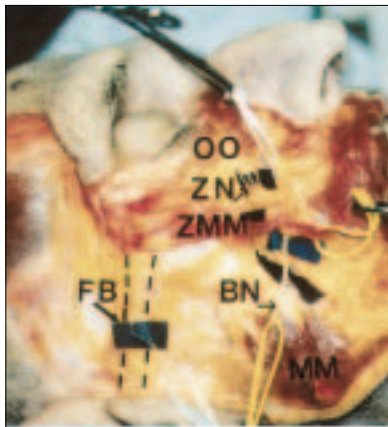


Figure 7. Anatomic preparation shows the zygomatic nerve branches coming from the buccal nerve. The zygomatic nerve branches extend from the zygomaticus major muscle toward the undersurface of the orbicularis oculi muscle. More laterally, the frontal branch of the facial nerve (3 fascicles) cross over the zygomatic arch. OO, Orbicularis oculi; ZN, zygomatic nerve; ZMM, zygomaticus major muscle; BN, buccal nerve; FB, frontal branch.

innervate the lower orbicularis oculi muscle (Figure 6). In 1 (4.1%) specimen, we found the buccal branch to be the predominant branch, with most of the fascicles of the plexus coming from this nerve (Figure 7). This finding was of particular interest because it may explain some cases of orbicularis oris-orbicularis oculi synkinesis. In 4 (16.6%) specimens, the buccal nerve contributed significantly with branches toward the zygo-orbicular plexus.

The independent contribution of the buccal nerve toward the upper orbicularis oculi, depressor supercillii, corruga-

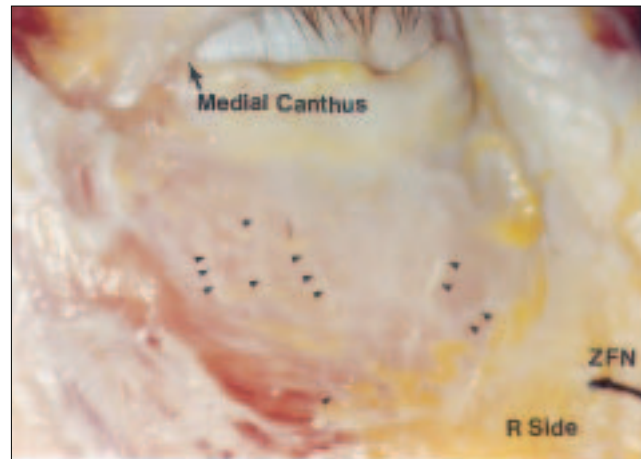


Figure 8. Anatomic preparation of the right side of the face shows the motor innervation of the orbicularis oculi muscle traveling under the deep surface of the muscle, covered by fine fascia and periosteum. Arrows indicate motor branches. ZFN, Zygomaticofacial nerve.

tor, and procerus muscles was not mapped. However, we are aware of the study of Terzis and Daigle,¹¹ which states that the corrugator muscle is innervated by branches coming from the midface. In our cadaver specimens, the branches of the zygo-orbicular plexus could be seen from the deep surface, through the periosteal layer of the midface (Figures 8 and 9). Four patterns of distribution of the zygo-orbicular plexus were found. They are depicted in Figure 10.

Microscopic Examination

The nerves of the orbicularis oculi muscle approach the muscle from its deep surface, protected by variable amounts of fat. They are in close proximity to the periosteum. The approach is at a 90° angle. These branches are then distributed into the muscle fibers (Figures 11 and 12). Some of these intramuscular nerves continue traveling from the orbital portion of the orbicularis oculi muscle to the preseptal and pretarsal portions. Laterally, some nerve fascicles travel toward the upper orbicularis oculi muscle. Medially, some of the nerve fascicles travel to the upper orbicularis oculi, corrugator, depressor supercillii, and procerus muscles.

The orbicularis oculi muscle, which is thick at the orbital portion, is thinner at the preseptal portion and becomes more attenuated at the preseptal-pretarsal junction. It then thickens at the pretarsal portion. It seems that in the orbital and pretarsal portions, the orbicularis oculi muscle has 2 layers very similar to the bilayer distribution of

the platysma/SMAS system in some areas of the face.¹² The significance of this is not known. The superficial layer is adherent to the dermal layer of the orbicular skin. It is feasible that the superficial layer is functionally related to mimetic activity and the deep layer is related to dynamic support of the lower eyelid and orbital fat pad. The correlation of the macroscopic dissection, the 3.5× loupe magnification dissection, and the microscopic preparations were critical for identification of the nerves to the orbicularis oculi muscle. The sensory branches of the zygomaticofacial nerve and the infraorbital nerve travel toward the muscle and very quickly become superficial to distribute in the supramuscular plane toward the skin. Their orientation and approach to the orbicularis oculi muscle are also different from the orientation and approach of the motor branches.

Discussion

In view of the operations that have traditionally been performed for rejuvenation of the lower eyelid and midface access, the findings of our cadaver dissection are clinically significant, particularly concerning the newer techniques that have been proposed by many authors. The standard skin/skin muscle blepharoplasty has been associated with a high rate of ectropion—as high as 20% in some studies.⁸ Although most plastic surgeons use this technique, tran-

secting and subsequently denervating the pretarsal portion of the orbicularis oculi muscle, why do we not see a higher rate of ectropion? It is feasible that some patients, particularly younger ones, have the capacity for a higher rate of neurotization of the pretarsal portion of the muscle. Furthermore, techniques in which orbicularis suspension or canthopexy is performed place the preseptal

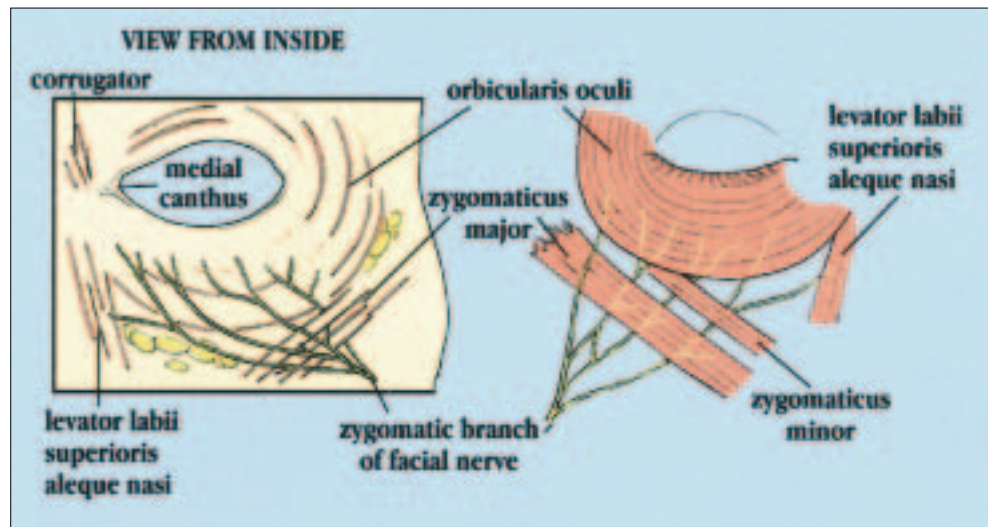


Figure 9. Orientation and position of the zyo-orbicular plexus. The left side of the figure shows the artistic conceptualization of the anatomic specimen shown in Figure 8. After innervating the zygomatic major muscle, the branches of the zyo-orbicular plexus dive under the zygomatic minor and orbicularis oculi muscles.

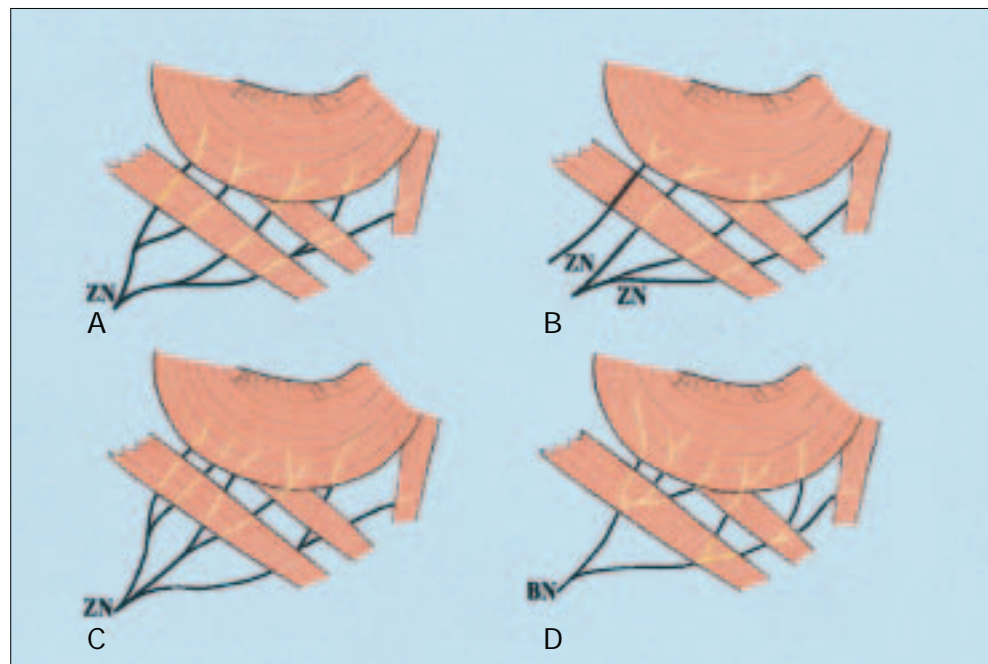


Figure 10. The 4 different distribution patterns of the zyo-orbicular plexus. The patterns were observed in our specimens with the following frequency: A, 54%; B, 33.3%; C, 8.3%; D, 4.1%.

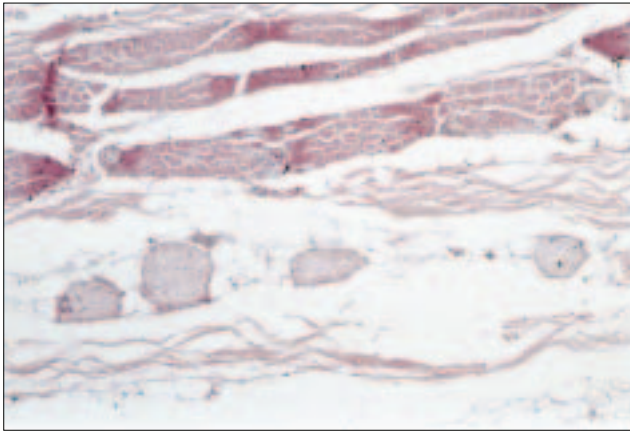


Figure 11. This histologic preparation (hematoxylin-eosin, original magnification $\times 1000$) shows the position of the motor nerve fascicles of the orbicularis oculi muscle. They travel under and perpendicular to the muscle fibers.

portion of the muscle against the pretarsal portion in a more favorable position for neurotization.¹³ Therefore, the fact that canthopexies do diminish the rate of ectropion might be due not only to the mechanical aspect of the canthopexy support but also to the favorable relocation of the muscle fibers for neurotization. Here, we propose a whole field for investigation—a search for methods to accelerate and improve the rate of neurotization associated with the described techniques.

It is likely that access to the midface via a lower blepharoplasty incision puts the innervation to the orbicularis oculi muscle at higher risk than the standard lower blepharoplasty alone. Although the senior author's 1994 description of the midface access through the lower blepharoplasty incision⁴ involved a limited lower eyelid incision (see Figure 4 in the article cited), it was not emphasized because at that point we did not know the significance of the innervation of the orbicularis oculi muscle. Later variations of the midface access with more extended incisions have shown a significantly higher rate of ectropion in comparison with the lower blepharoplasty alone. Hurwitz and Raskin¹⁰ reported a 50% rate of eyelid malposition and ectropion using the transblepharoplasty subperiosteal approach for cheek lift. This may be due to the more extended incision in the muscle plane and the subsequent traction to the lower orbicularis oculi muscle for exposure of the midface through the open approach. Again, the routine use of canthopexy might counteract the potential for an even higher rate of ectropion. Techniques that approach the midface through the lower eyelid, dissect from the deep layer of the preseptal

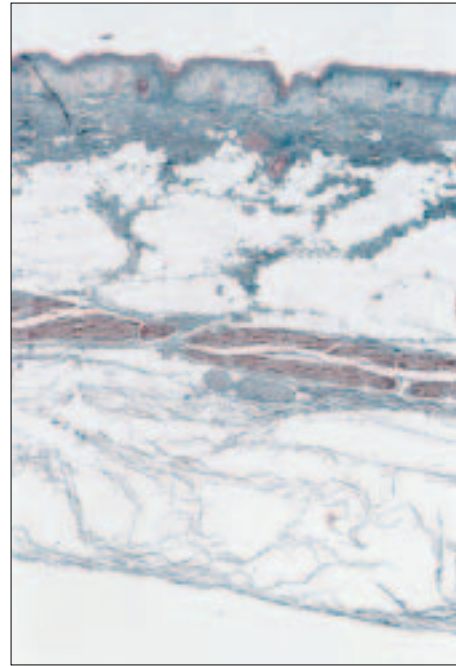


Figure 12. This histologic preparation (Masson trichrome, original magnification $\times 40$) shows the orbicularis oculi muscle and its motor innervation. The nerves are located under and perpendicular to the muscle fibers.

and orbicular portions of the orbicularis oculi muscle, and change the plane of dissection from deep to the orbicularis oculi muscle to the superficial surface of the zygomaticus major muscle may place the innervation of the orbicularis oculi muscle at much higher risk.

It is probable that temporary paralysis of the lower eyelid with temporary ectropion is more common than is widely thought. Most patients with this condition will recover but will develop scleral show or lagophthalmos. Some of the repair process can develop into synkinesis between the zygomaticus major muscle and the orbicularis oculi muscle, which is perhaps the most common synkinesis seen during face lift surgery. The obvious reason is found in the anatomy of the zygo-orbicular plexus that innervates both the zygomaticus major and orbicularis oculi muscles. Therefore, cross-neurotization is probably a very common event after partial injury of this plexus.

Conclusion

This study raises a compelling question: is the zygo-orbicular plexus the main path of innervation to the lower orbicularis oculi muscle, or is it an alternative path? Higher-definition anatomic and histologic studies as well as electrophysiologic studies are necessary to definitively

answer this question. Nevertheless, the anatomic studies performed in this investigation lead to a number of preliminary conclusions.

According to our observations, the lower eyelid orbicularis oculi muscle is innervated by branches of the zygomatic nerve that penetrate the muscle from its inferior aspect rather than its lateral aspect. These nerves travel perpendicular to the muscle fibers to reach the periorbital portion of the muscle, then pass through the preseptal portion, finally reaching the pretarsal muscle fibers.

The zygomaticus major, zygomaticus minor, and orbicularis oculi muscles are innervated by the zygo-orbicular plexus. Fibers from this plexus continue to innervate the upper orbicularis oculi, depressor supercilii, corrugator, and procerus muscles. Incisions that split the pretarsal from the preseptal portions denervate the pretarsal orbicularis oculi muscle. Techniques that change the plane of dissection from deep to the orbicularis oculi muscle to superficial to the zygomaticus major muscle may put the zygo-orbicular plexus in greater jeopardy.

This anatomic study and the clinical observation of the techniques might explain one of the causes of the high rate of ectropion and scleral show after these procedures. Furthermore, these observations might explain the occasional paralysis of the entire lower orbicularis oculi muscle and the occasional synkinesis of the associated muscle groups seen with these techniques. ■

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