Anatomy of the Supratrochlear Nerve: Implications for the Surgical Treatment of Migraine Headaches

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Background: Migraine headaches have been linked to compression, irritation, or entrapment of peripheral nerves in the head and neck at muscular, fascial, and vascular sites. The frontal region is a trigger for many patients' symptoms, and the possibility for compression of the supratrochlear nerve by the corrugator muscle has been indirectly implied. To further delineate their relationship, a fresh tissue anatomical study was designed.

Methods: Dissection of the brow region was undertaken in 25 fresh cadaveric heads. The corrugator muscle was identified on both sides, and its relationship with the supratrochlear nerve was investigated.

Results: The supratrochlear nerve was found in all 50 hemifaces. Three potential points of compression were uncovered in this investigation: the nerve entrance into the brow through the frontal notch or foramen, the entrance of the nerve into the corrugator muscle, and the exit of the nerve from the corrugator muscle. The nerve generally bifurcates within the retro–orbicularis oculi fat pad, and these branches enter into one of four relationships with the corrugator muscle: both branches enter the muscle, one branch enters the muscle and one remains deep, both branches remain deep, and the branches further branch into ever smaller filaments that cannot be identified cranially.

Conclusions: Some patients are nonresponders to migraine decompression techniques that address the supraorbital nerve. The supratrochlear nerve may be compressed in these patients. A standard corrugator resection that comes more medially within 1.8 cm of the midline may be beneficial. The morphology of the frontal notch/foramen must be examined and addressed if necessary. (*Plast. Reconstr. Surg.* 131: 743, 2013.)

Migraine headache is a debilitating condition that affects almost 35 million Americans.[1] Traditional migraine management has focused on the treatment of this syndrome through chemotherapeutics such as the triptans.[1] Clinical evidence has shown that the decompression of peripheral nerve trigger points is successful in alleviating migraines.[2–4] A recent article discussed a randomized, prospective trial where "sham surgery" was compared with actual nerve decompression in 26 and 49 patients, respectively, with complete elimination of symptoms achieved in only one patient in the sham group compared with 57 percent in the actual surgery

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group,[5] which was statistically significant. This adds robust evidence to the literature that this is a valid concept and technique with which to address migraine headache symptoms.

Peripheral nerve decompression, however, is not a new concept. It has been used for many years for the treatment of upper extremity nerve compression such as carpal tunnel syndrome.[6] This strategy has also been used in the head and neck for the treatment of trigeminal and occipital neuralgias.[7,8]

One of the most important trigger sites for migraine headaches is the frontal region. Patients with pain symptoms in this area complain of their migraine consistently originating in the frontal and periorbital region. This is the area in which it was first seen that decompression techniques may lead to improvement in migraine symptoms, as it was recognized retrospectively that patients who underwent cosmetic brow-lift procedures with concomitant corrugator resection saw amelioration of their symptoms.[2] Since that time, the corrugator muscle and its relationship to the supraorbital nerve has been investigated in great detail.[9] Anatomical studies have shown that the supraorbital nerve sends branches through the corrugator muscle in 73 percent of studied hemifaces,[10] which may serve as points of compression because of their intimate relationship with the muscle.

Details concerning the path of the supratrochlear nerve through the brow are insufficient to accurately guide surgical decompression at this point. To further our specific understanding of the potential compression points of the supratrochlear nerve by the orbital septum, periorbital retaining structures, and corrugator muscle, an anatomical study was undertaken.

RELEVANT ANATOMY

The supratrochlear nerve is a peripheral nerve that supplies sensation to the skin and soft tissue of the glabella, lower medial portions of the forehead, upper eyelid, and conjunctiva. It is an end branch of the frontal nerve, which is the largest branch of the trigeminal nerve's ophthalmic division (V_1).[11]

The frontal nerve passes into the orbit through the superior orbital fissure, and midway through the orbit it divides into the supratrochlear and supraorbital nerves. The supratrochlear nerve runs along the medial roof of the orbit, going between the trochlea and the supraorbital foramen to exit into the deep tissues of the forehead out of the frontal notch.

Miller et al. have conducted perhaps the most extensive examination of the supratrochlear nerve. In an effort to highlight the nerve distance from midline to guide safe brow-lift and muscular resection techniques, they looked at the distance of the nerve from the midline.[12] It was demonstrated that the nerve is never closer than 1.6 cm from the midline, and thus they leave a 3.2-cm "safe zone" to prevent inadvertent iatrogenic nerve injury. In their study, they also demonstrated that just one of 50 skulls (2.0 percent) had a true bony foramen for the supratrochlear nerve.

Guyuron et al. have discussed visualization of the supratrochlear nerve penetrating the corrugator muscle.[13] Knize has confirmed this, stating that the nerve clearly enters the muscle and quickly arborizes into three or four small branches.[14] However, detailed understanding of this relationship remains unelucidated. Clearly, the supratrochlear nerve's entrance into, path through, and exit from the corrugator muscle all contain potential compression points that may be locations of migraine incitation in susceptible patients.

It has been theorized that some of the nonresponders to surgical decompression for migraine surgery might have not experienced surgical benefit because this specific trigger point was not actually released because of the muscular resection not reaching far enough medially. A cadaveric investigation into the anatomical location of the supratrochlear nerve compression points in the brow region was thus undertaken.

MATERIALS AND METHODS

Twenty-five fresh cadaveric heads were obtained for dissection. All heads were acquired from the Willed Body Program at the University of Texas Southwestern Medical Center in Dallas, Texas. Specimens used were all dissected within 7 days postmortem. None of the heads chosen had a history of trauma or surgery to the area or any sign of congenital craniofacial anomaly.

Dissection was undertaken using surgical loupes with 3.5× magnification. All heads were shaved and placed supine in a Mayfield neurosurgical headrest. Forty heads were marked with a blue marker in a cruciate pattern with the intersection at the glabella (Fig. 1) in preparation for open direct approach to dissection. The remaining 10 heads were approached through an open coronal incision. The coronal approach was added to verify the anatomy through an incision that is not used by the primary author (J.E.J.) but could be used by others.

Flaps were raised in the subcutaneous plane, with caution used to avoid injury to the musculature lying deep to the superficial fascia and the cutaneous nerve branches. This dissection exposed orbicularis

Fig. 1. Marking for incision and flap dissection for exposure.

oculi, frontalis, depressor supercilii, and procerus. The corrugator was identified more laterally as it entered a more superficial plane.

When the corrugator was exposed, a plane was entered caudal to the inferior border of the muscle, with blunt dissection performed to expose the area cranial to the orbicularis retaining ligament where the supratrochlear and supraorbital nerves are found. The entrance of these nerves into the brow region was defined by further reflecting the muscle superiorly and exposing the orbital contents inferiorly. The foramen of the supratrochlear nerve was identified and its morphology was noted. This point triangulated through measurements relative to the midline and from a horizontal line through the lateral canthi. The supratrochlear nerve branches were traced from their entrance into the brow region through the foramen/notch along the periosteum of the frontal bone through the deep glide plane space into the corrugator. The nerve entrance into the corrugator and its branching patterns were noted. The nerve was dissected, where possible, through the corrugator into the more superficial plane.

Photographs of the relevant points were taken. Points of measurement were recorded in a Microsoft Excel database (Microsoft Corp., Redmond, Wash.). Means were calculated for the distances from the horizontal line through the canthi and from the midline.

RESULTS

In all 50 facial halves, the supratrochlear nerve was identified at its entrance into the brow. This entrance was through a frontal notch in 38 facial halves (72.0 percent). This notch had a distinct fibrous band serving as the "floor" of the notch in all 38 (72.0 percent) (Figs. 2 and 3). In 34 facial halves (68.0 percent), the nerve passed through the notch. In four facial halves (8.0 percent), the nerve actually pierced through the fibrous band itself. In four specimens (8.0 percent), the band appeared much broader and seemed to greatly constrict the nerve, with flattening of an otherwise round nerve as it passed through the notch. In three facial halves (6.0 percent), the frontal notch was a large notch through which both the supraorbital and supratrochlear nerves passed. In nine facial halves (18.0 percent), there was a true bony foramen. When present, this foramen was found at a mean ± SD of 4 ± 0.4 mm cranial to the orbital rim. In three halves (6.0 percent), there was no identifiable frontal notch, but the nerve entered the orbital region straight through the orbital septum (Fig. 4). The frontal notch was found at a mean of 17.5 ± 2.31 mm from the midline.

Most frequently, the nerve was found to split into two separate branches before entering the corrugator muscle within the substance of the retro–orbicularis oculi fat (Fig. 5, *above*). In 34 facial halves, both supratrochlear branches entered into the muscle and were found to exit at its cranial border, getting into a more superficial plane at this point approximately 15 mm superior to the orbital rim (68.0 percent) (Fig. 5, *center*). Intramuscular dissection revealed the branches running between the oblique and transverse heads of the muscle (Fig. 5, *below*). In six more halves (12.0 percent), the branches never actually entered the muscle but stayed deep to it at all times; these branches all appeared to become more superficial at the same point—approximately 15 mm superior to the orbital rim. In two of the halves (4.0 percent),

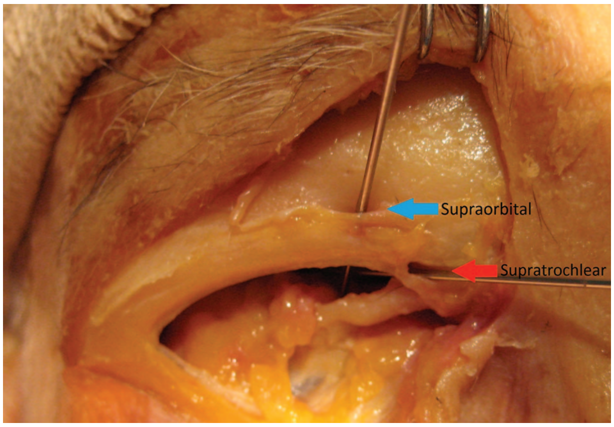

Fig. 2. Photograph of the fibrous band present in 100 percent of specimens (medial, with probe) and a separate probe through the more lateral supraorbital notch (with fibrous band also).

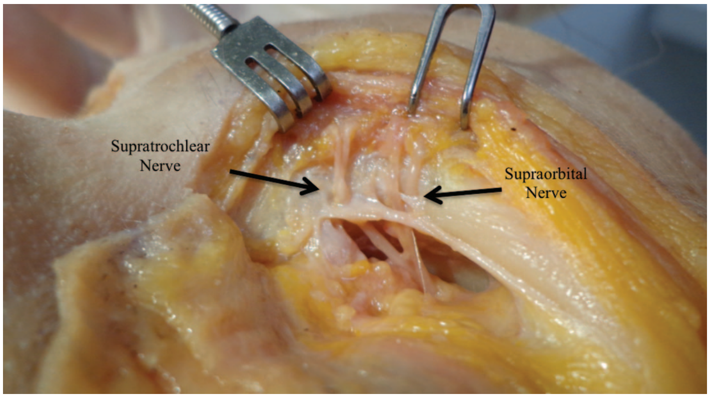

Fig. 3. Composite photograph of the supratrochlear and supraorbital nerves at the orbital rim or frontal exit. The supratrochlear nerve has a bony notch and a dense fibrous completion of the tunnel. Note the intraconal component of both nerves.

Fig. 4. In some cases, there was no identifiable frontal notch; the nerve passed straight through the orbital septum, as shown.

a pattern was found where one branch entered the muscle and the other stayed deep to it at all times. In eight facial halves (16.0 percent), the branches were small and appeared to taper out in the substance of the muscle so they could not be traced cranially. The nerve entrance into corrugator was found to be at a mean of 18.76 ± 2.94 mm lateral to the midline (Fig. 6). The location of the exit of the supratrochlear nerve from the corrugator/entrance into the superficial plane was seen to be at a mean of 19.62 ± 2.94 mm lateral to the midline.

The relationship between the corrugator muscle and the supratrochlear nerve can be classified into three different types. Type I is the most common (84.0 percent), where the nerve branches enter the muscle and wind their way more superficially through the muscle to exit into the plane of the frontalis at its cranial border; however, in eight of these facial halves (16.0 percent), the nerve tapered out within the substance of the muscle. Type II (4.0 percent) is where one branch runs intramuscularly and the other branch runs deep to the muscle at all times. Type III (12.0 percent) is where both branches remain deep to the corrugator at all times and then become more superficial at its cranial border (Fig. 7).

A noteworthy structure in this region was the supratrochlear artery, which was found in 36 of 50 of the hemifaces (72.0 percent). The supratrochlear artery was noted to exit through the frontal notch and was always medial to the supratrochlear nerve; in 12 facial halves, the artery crossed underneath the nerve, going from medial to lateral, within the substance of the retro–orbicularis oculi fat before the nerve entrance into the corrugator (Fig. 8).

The supraorbital nerve was examined as well. Although the details of the anatomical relationship between the supraorbital nerve and the corrugator were published previously, the distance of the nerve exit through the supraorbital foramen from the midline was not published. As noted previously, in three hemifaces (6.0 percent) there was a shared notch with the supratrochlear foramen. The nerve entrance into the brow was noted in 27 other hemifaces. It was seen to come through a true bony foramen in 11 of these 27 (40.7 percent) and a notch with a band in 16 (59.3 percent) (Table 1). When there was a true foramen, this was seen at a mean of 4 mm superior to the orbital rim. The mean distance of the notch/foramen from the midline was 26.88 ± 3.44 mm.

DISCUSSION

The course of the supratrochlear nerve through the brow region has been explored in 50 hemifaces. The nerve leaves the orbit and enters

Fig. 5. (*Above*) The supratrochlear nerve travels through the substance of the retro–orbicularis oculi fat before entering the corrugator muscle. (*Center*) It exits the muscle at its cranial border. (*Below*) The supratrochlear nerve is shown running within the muscle.

the brow at a mean of 1.75 cm from the midline; this entrance was through a frontal notch in 72 percent of the facial halves explored and through a true foramen in 18 percent. This was significantly more common than previously reported (2.0 percent). The nerve generally becomes two branches in the retro–orbicularis oculi fat superficial to the periosteum of the frontal bone. There are three general patterns of the anatomical relationship between the supratrochlear nerve and the corrugator muscle. Type I (84.0 percent) is where both branches of the supratrochlear nerve enter the corrugator. Type II (4.0 percent) is where one of the supratrochlear nerve branches becomes more superficial to enter the corrugator and the other one stays deep to the plane of the muscle. Type III (12 percent) is where both nerve branches stay deep to the muscle at all times. Regardless of classification, all nerve branches appear to enter a superficial plane at a point cranial to the muscle approximately 1.5 cm above the orbital rim. The nerve entrance into the corrugator was found to be at a mean of approximately 1.9 cm from the midline; it was seen to course laterally 1 mm within the substance of the muscle, as its mean exit was seen to be at 2 cm from the midline.

It is interesting to note that in the vast majority of specimens dissected, both supratrochlear nerve branches enter the corrugator muscle, although the clinical significance of this is uncertain. However, it is likely that the 12.0 percent of patients who have a type III pattern would be less morphologically prone to intramuscular compression, as the nerves are never within muscle. The problem with this theory is that large proportions of the population do not have migraine headaches, which would be expected if migraines had their genesis in muscular compression only. There is clearly more to the story; perhaps the patients with type II anatomy, where one of the branches is in the muscle and one stays deep, are more morphologically prone to migraine headaches because one branch sits clearly within the muscle substance, where it may be subject to greater compression.

The supraorbital nerve location and morphology were also reexamined and confirmed against the results of a previous study from this group.[10] In that publication, the nerve exit through the supraorbital foramen was not detailed; however, it was seen that the nerve entrance into the brow came through a foramen in approximately 40 percent and through a notch in 60 percent. The mean distance of this nerve entrance into the brow from the midline was approximately 2.7 cm. The results of this investigation are very similar, in that the mean distance of the supraorbital region notch/foramen from the midline is 26.88 cm, and that the nerve enters the brow through a notch in 59.3 percent of specimens and through a foramen in 40.7 percent. Also, the results from this study are similar to the results from a previous investigation into this anatomical region and its relevance to the subcutaneous brow lift by Miller et al.[12] In that

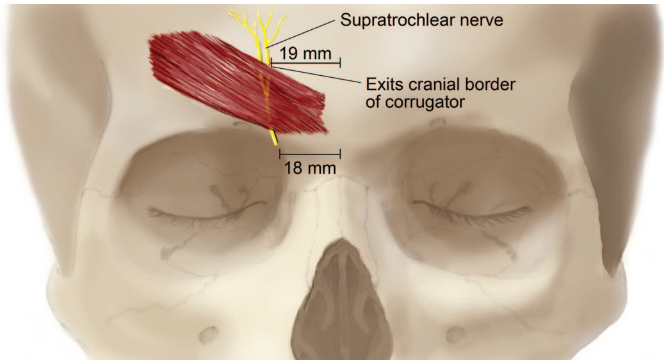

Fig. 6. Illustration depicting the frontal view of the pathway of the supratrochlear nerve.

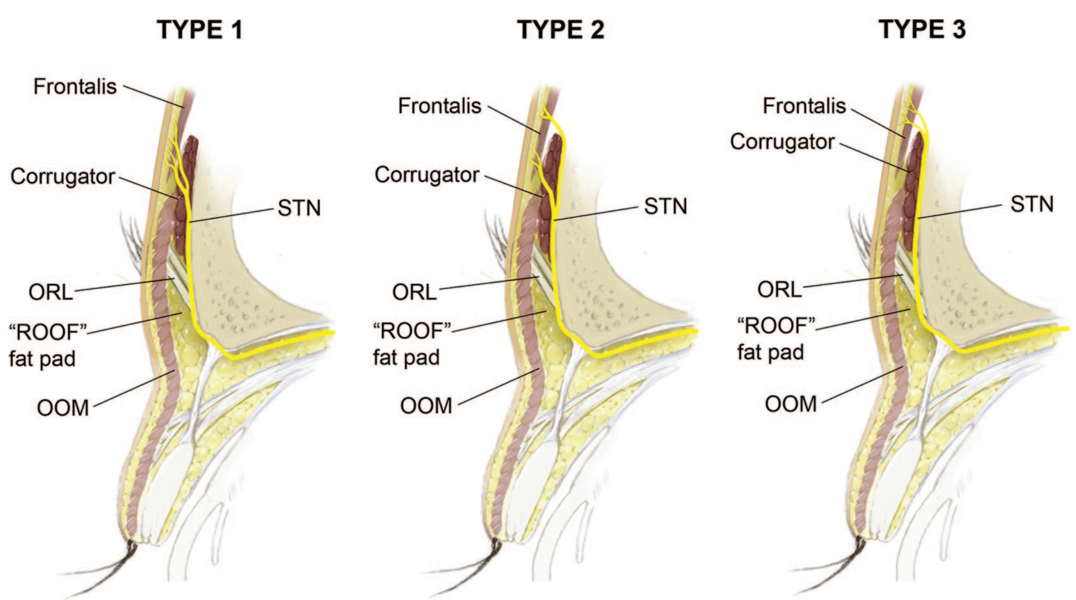

Fig. 7. Illustrations of the three classifications of the supratrochlear nerve relationship with the corrugator muscle. *ORL*, orbicularis retaining ligament; *ROOF*, retro–orbicularis oculi fat; *OOM*, orbicularis oculi muscle; *STN*, supratrochlear nerve.

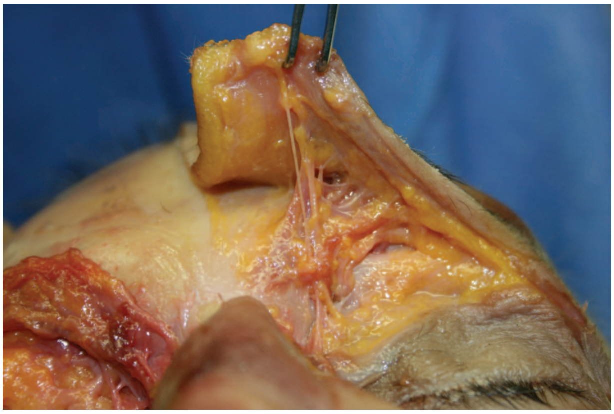

Fig. 8. The supratrochlear artery is shown crossing underneath the nerve within the retro–orbicularis oculi fat.

project, the authors found the frontal notch at a mean of 1.97 cm from the midline (compared with 1.75 cm in this study); the supraorbital foramen was found at a mean of 2.61 cm from the midline (compared with 2.68 cm in this study) but was found to be present only 2 percent of the time as a true foramen compared with 18 percent of the time in our study. The authors rightly concluded in that study that there is a safe zone of approximately 3 cm at the glabellar midline where interbrow muscular resection can be performed. In their technique, this safe zone is approached from above through the subcutaneous plane. Others have described using a transpalpebral approach to this zone for brow lift through muscular

Table 1. Frontal Notch/Foramen Patterns

	No.	Notes
Facial halves	50	
Frontal notch	38	27 nerves through "normal" notch; 4 nerves through band/floor; 4 thick bands constricting nerve within notch; 3 large notches through which both supratrochlear and supraorbital nerves passed
True frontal foramen	9	
Nerve straight through orbital septum	3	

resection.[13,14] The reader should note that either of these approaches can also be used to resect muscle that may be entrapping the supratrochlear and supraorbital nerves in an effort to decompress them and achieve relief from migraine symptoms.

This study answers some questions and leaves others unanswered. The supratrochlear artery was seen to exit through the frontal notch and travel medial to the nerve, and in approximately one-third of the specimens, the artery crossed underneath the nerve to travel lateral to it before the nerve entered the corrugator. However, the detailed relationship between the artery and nerve remains elusive. The point at which the artery crosses underneath the nerve in those respective specimens was not identified. How often this relationship exists, what form it takes (i.e., a spiral versus single-cross), and where it is in relation to the rim, midline, and so forth, may likely be better elucidated in a focused study using arterial injection techniques. The implications of this may be significant, as vessel/nerve interactions can be a source of compression, as theorized in other areas of the body such as the occipital region of the neck,[3,15] the auriculotemporal region,[16] and in Guyon's canal.[17]

Also, the intraorbital course of the supratrochlear nerve remains to be further explored. Although we know that the nerve branches from the supratrochlear deep in the orbit to then run along the medial roof between the trochlea and the supraorbital foramen, this is insufficient for the surgeon who wishes to enter the orbit to decompress this nerve for the purposes of migraine surgery. Some patients complain of headache genesis in the superior aspect of the orbit, and it is possible that the nerve is impinged within the orbit as well. Future studies of the nerve course within the orbit may reveal clinically relevant information concerning the relationships between the supratrochlear nerve, the trochlea, and the ligamentous sling[18] within the upper orbit.

Guyuron et al. have demonstrated that corrugator resection during brow rejuvenation facilitates symptom relief in 80 to 83 percent of migraineurs.[19,20] In a large prospective study, it was seen that 55 percent of patients experienced complete resolution after corrugator myectomy, with 28 percent experiencing partial improvement. It was estimated that the migraine improvement was secondary to decompression of the supraorbital nerve. Although these were outstanding results bringing life-changing relief to many migraine patients, it was felt that there could be anatomical reasons for nonresponse to decompression. The supratrochlear nerve remained formally unstudied, forming the impetus for this investigation. It is possible that some of the nonresponders to this "frontal decompression" have incomplete supratrochlear nerve decompression as their compressive cause. This demonstrates the need to release the muscle medially. This is interesting to note, as in cosmetic rejuvenation of the brow, the corrugator muscle has been discussed as being incompletely addressed laterally rather than medially.[21]

Fibrous bands and fascial inscriptions are well recognized as points of peripheral nerve compression.[22] In patients with this morphology, cutting the band would be a simple method for supratrochlear nerve decompression. Also, 18 percent of specimens had a true foramen. A bony boundary on all sides of the nerve would also seem to predispose to greater compression. Bony foramina have been previously recognized as points of peripheral nerve compression.[23] This nerve morphology could be released by osteotomizing the frontal bone to the foramen in an effort to release the nerve, as is sometimes done in craniofacial surgery.

CONCLUSIONS

The supratrochlear nerve has three potential points of compression as it runs through the brow region. One is its entrance into the brow, which in most specimens took the form of a notch rather than a true foramen. In 8 percent of the specimens explored, the fibrous band that formed the floor of the notch was very large and seemed to constrict the exiting nerve, as evidenced by flattening of the nerve. In another 8 percent of specimens, the nerve actually passed through the band itself.

These two particular morphologies may predispose the nerve to greater potential compression in comparison with a notch with a normal fibrous band or a notch with no band. A second potential compression point is where the nerve enters the corrugator muscle. In most of the specimens, there was at least one branch that entered the corrugator. Cutting the muscle through an open coronal, endoscopic, or upper blepharoplasty approach is feasible, and extension of this myotomy to within 1.8 cm of the midline would likely ensure complete decompression. Distal to the muscle, the nerve becomes more superficial and divides into many smaller branches. What remains to be uncovered are any potential intraorbital points of compression, and whether or not there are entangling relationships between the nerve and the supratrochlear artery.

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