The Zygomaticotemporal Branch of the Trigeminal Nerve: Part II. Anatomical Variations

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Background: Musculofascial and vascular entrapments of peripheral branches of the trigeminal nerve have been thought to be trigger points for migraine headaches. Surgical decompression of these sites has led to complete resolution in some patients. The zygomaticotemporal branch of the trigeminal nerve has been shown clinically to have sites of entrapment within the temporalis. A cadaveric study was undertaken to elucidate and delineate the location of this nerve's foramen and intramuscular course.

Methods: The periorbital and temporal regions of 50 fresh cadaveric hemiheads were dissected. The deep temporal fascia and lateral orbital wall were exposed through open dissection. The zygomaticotemporal nerve was located and followed through the temporalis muscle to its exit from the zygomatic bone. The muscular course was documented, and the nerve foramen was measured from anatomical landmarks.

Results: In exactly half of all specimens, the nerve had no intramuscular course ($n = 25$). In the other half, the nerve either had a brief intramuscular course ($n = 11$) or a long, tortuous route through the muscle ($n = 14$). The foramen was located at an average of 6.70 mm lateral to the lateral orbital rim and 7.88 mm cranial to the nasion-lateral orbital rim line, on the lateral wall of the zygomatic portion of the orbit. Two branches were sometimes seen.

Conclusions: The zygomaticotemporal branch of the trigeminal nerve is a site for migraine genesis; surgical decompression or chemodenervation of the surrounding temporalis can aid in alleviating migraine headache symptoms. Advances in the understanding of the anatomy of this branch of the trigeminal nerve will aid in more effective surgical decompression. (*Plast. Reconstr. Surg.* 126: 435, 2010.)

In the late 1990s, neurologists seeking a new treatment paradigm for headaches began to use botulinum toxin type A to paralyze or relax the pericranial musculature.[1–4] These efforts were met with good clinical success. At the same time, it was found by one of the senior authors of this article (B.G.) that a number of patients who were chronic migraine sufferers had amelioration of their condition following aesthetic rejuvenation of the brow.[5] A retrospective survey study was performed to examine this effect in greater detail, and it was found that of almost 40 patients who had experienced chronic migraine headache, 79.5 percent experienced improvement in their symptoms immediately after surgery; 38.5 percent of these previous migraine sufferers saw a total elimination of headaches. This inspired a prospective look into the possibility of permanent migraine relief through surgical decompression of the supraorbital nerve by complete resection of the corrugator muscles. In that investigation, over 55 percent of patients with migraine experienced a complete resolution following corrugator removal; another 28 percent of patients saw partial improvement in their symptoms.[6]

Subsequent to these findings, efforts were made to discover why some patients were only

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seeing partial improvement and why others did not receive any lasting benefit at all. Previous theories on migraine genesis expounded a central, vascular cause for migraine headaches[7]; the treatment of migraine headaches with decompression of peripheral nerves in the head and neck was a completely new paradigm. Although the classic migraine theories could not be discounted as an explanation for why there were some patients who did not respond, it was realized that perhaps release of the supraorbital nerve was anatomically incomplete or inadequate, as there may be other trigeminal nerve branches that were contributing to the causation of migraine headaches.[8–12] To that end, other peripheral nerves in the head and neck region were investigated. One of the first areas to be explored was that of the occipital region—specifically, the greater, lesser, and third occipital nerves—as many patients related the genesis of their symptoms to be in close geographic proximity to these nerves' territories.[13–16]

Out of these studies, surgical techniques were developed that subsequently resulted in clinical improvement that was more complete and more durable. Since that time, the understanding of migraine genesis and its surgical treatment has advanced greatly. Four "trigger regions" are now recognized: frontal, occipital, temporal, and nasal.[10] Botulinum toxin type A is used not only as treatment but also as a diagnostic tool to prognosticate whether a patient might respond to surgical decompression of the respective injection site, in the same way that steroid injections are used to diagnose which patients might benefit from carpal tunnel release.[17]

Two of the senior authors (J.E.J. and B.G.) have added decompression of the zygomaticotemporal branch of the trigeminal nerve to their methods for treatment of frontal migraine headaches. It is felt that this branch is a culprit in some migraines, and botulinum toxin injection of the temporalis in the region of its exit from the deep temporal fascia has been shown to be clinically effective. Intraoperative dissection of this nerve demonstrated that previous studies may not have addressed the intramuscular course of the nerve accurately enough, and that the location of the nerve foramen was still not properly elucidated. Furthermore, botulinum toxin injection into the temporalis has led to temporary lateral rectus palsy in four patients of one of the senior authors (J.E.J.); because the injection site is located far lateral to the lateral rectus (and clearly outside of the orbit), it was also felt that there may be multiple foraminae in the lateral orbit, conveying the toxin into the orbit where it might affect the lateral rectus. These questions were addressed in an anatomical dissection study in fresh cadavers.

RELEVANT ANATOMY

The zygomaticotemporal branch is a terminal branch of the maxillary division (V_2) of the trigeminal nerve. The zygomatic nerve arises from the maxillary division and enters the orbit through the inferior orbital fissure; along the lateral wall of the orbit, it divides into the zygomaticotemporal and zygomaticofacial nerves. The zygomaticotemporal branch is a sensory nerve that provides sensation to the skin of the temple region.[18] The zygomaticotemporal branch is not a widely discussed structure within the literature; a PubMed search using "zygomaticotemporal nerve" yielded just 18 results.[19]

Recently, interest in the anatomical course of this nerve has increased. This may be attributable to the realization that the nerve may be involved in migraines[11] and posttraumatic pain syndromes.[20] Because of this resurgent interest, some surgeons and anatomists have delved into its study. A group from Korea demonstrated that the nerve emerged from the orbit into the temporal fossa at approximately 14 mm inferior to the zygomaticofrontal suture and 10 mm lateral to the lateral margin of the orbit.[21] They also demonstrated that the nerve ran within the deep temporal fascia in between the superficial and deep layers. In an article published in *Plastic and Reconstructive Surgery* in 2005, Totonchi et al.[11] took an in-depth look at the anatomical site where the zygomaticotemporal branch exits the deep temporal fascia to arborize within the subcutaneous tissues to provide sensation to the skin in this region. In that study, the lateral palpebral fissure was used as a landmark from which to topographically locate the site in question; it was found that the branch exited the deep fascia at 17 mm posterolateral and 6.5 mm cephalad to the commissure.

MATERIALS AND METHODS

A cadaveric investigation was designed to elucidate the pertinent anatomy on fresh tissue cadaver heads. Twenty-five fresh cadaveric heads were obtained from the Willed Body Program at the University of Texas Southwestern Medical Center in Dallas, Texas. The mean age of the cadaveric donors was 61 years; donors were between the ages of 42 and 86 years. All bodies were tested for human immunodeficiency virus and other communicable diseases before commencement of dissection. Heads were placed supine in a Mayfield neurosurgical headrest. Dissection commenced through an extended bicoronal incision, an extended upper blepharoplasty incision, and an incision over the caudal aspect of the zygomatic arch. Dissection over the forehead proceeded in a subperiosteal plane down to the orbital rim; dissection over the arch and temporal region proceeded above the deep temporal fascia, where the zygomaticotemporal nerve was identified. At this point, the exit of the nerve from the deep temporal fascia was noted; the nerve was carefully dissected down into the temporalis and/or the temporal fossa, to its exit from the foramen in the zygomatic bone of the lateral orbital wall. The course (intramuscular versus nonmuscular), its length, and the number of branches were noted. The position of the foramen was measured cranially from a horizontal line drawn from the nasion through the lateral orbital rim and laterally from the lateral orbital commissure. All data were entered into a Microsoft Excel database (Microsoft Corp., Redmond, Wash.), and means were calculated for the distances from the horizontal line through the protuberance and from the midline.

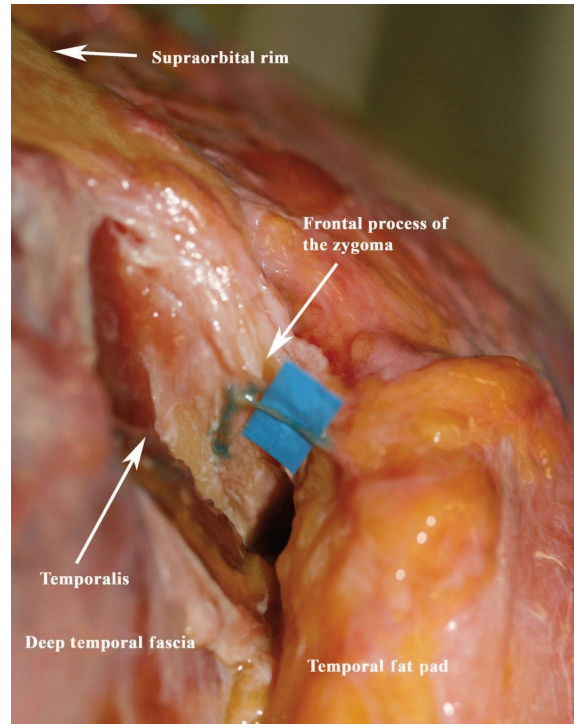

Fig. 1. View from above demonstrating a branch exiting the zygomaticotemporal foramen and the relevant anatomy. This branch had a short intramuscular course.

RESULTS

A total of 25 heads were dissected bilaterally. Eight of these heads were from female cadaveric donors and 17 were from male donors; mean age was 61 years. The zygomaticotemporal branch of the trigeminal nerve was found in all 50 hemiheads.

Table 1. Nerve Course in Relation to the Temporalis (*n* = 50)

Nerve Course	No. (%)
Short, straight, intramuscular	11 (22)
Long, tortuous, intramuscular	14 (28)
Extramuscular	25 (50)

Intramuscular Course

The nerve was easily located perforating the deep temporal fascia, typically found within the region previously described in part I of this project.[11] From here, the nerve was traced down to investigate its course. In 50 percent of the specimens, the nerve was found to have an intramuscular course (Fig. 1). Specifically, the nerve typically took one of two routes through the temporalis. The first one, which was found in 11 specimens (22 percent), was a very short intramuscular course where the nerve pierced the muscle after exiting the foramen in the lateral orbit. The second type was a longer course that was more tortuous through the muscle, from the foramen into the temporal fossa, and farther laterally to exit through the deep temporal fascia. This pattern was found in 14 specimens (28 percent) (Table 1). In the other half of the investigated specimens, it was found that the nerve did not travel through the temporalis muscle, but instead was located in between the temporalis and the lateral orbital rim, running strictly on top of the periosteum. It would then pierce the fascia within the temporal fossa, to run along the deep temporal fascia before entering more superficial layers (Fig. 2).

Multiple Branches

In 15 of the cranial halves, two branches were found (30 percent). In three of these (6 percent), there were two separate foramina, out of which a separate branch exited. In the other 12 specimens with multiple branches (24 percent), the nerve either arborized in the temporal fossa after exit from the bone or arborized within the belly of the temporalis.

Zygomaticotemporal Branch Foramen

Dissection down into the temporal fossa revealed the foramen of the zygomaticotemporal

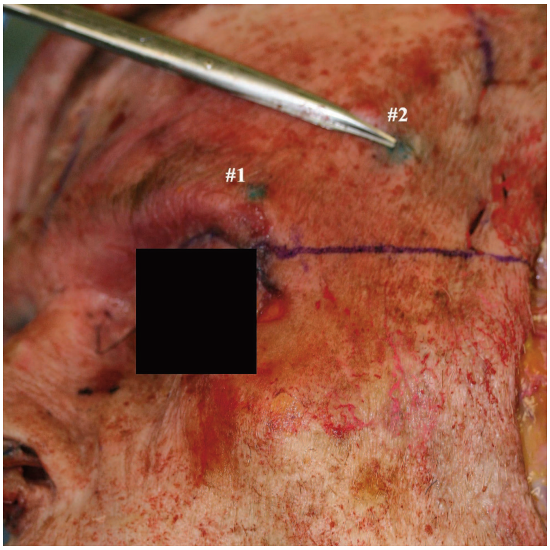

Fig. 2. Image demonstrating the surface anatomy of the important points where the nerve in this hemiface exits its foramen (*#1*), and then where it pierces the frontalis (*#2*). Unlike the hemiface depicted in Figure 1, this branch took an intramuscular course.

branch. In 47 specimens, there was one foramen (94 percent); in three, there were two foramina. The foramen had a mean ± SD location of 6.70 ± 6.12 mm lateral to the lateral orbital rim and 7.88 ± 6.90 mm cranial to a horizontal line from the nasion through the lateral orbital commissure. The foramen was always found posterolateral to the edge of the lateral orbital rim (Figs. 3 and 4).

DISCUSSION

Migraine headache is a debilitating chronic condition, with different authors stating that the condition affects between 12 and 28 percent of the general population.[22,23] Migraine headache not only has a severely limiting effect on the patient's life, but it also drains a great deal of productivity from society, as migraine sufferers are typically adults in their prime earning years.[24,25] Surgical decompression treatment for migraines is an exciting clinical reality, as it represents the possibility of bringing permanent relief to these patients.[26] This paradigm is what has spurred this investigation into the anatomy of a potential trigger point for migraine headaches.

Migraineurs typically complain of pain in three regions (either alone or in combination)—the periorbital region, the temple, and the back of the neck.[10] We know from anatomical studies that there are peripheral nerves that underlie these regions; specifically, the supraorbital and supratrochlear nerves in the periorbital region[5,6,8–10]; the zygomaticotemporal branch of the trigeminal nerve in the temple[11,12]; and the greater, lesser, and third occipital nerves in the posterior neck.[13–16] Investigation into these areas has uncovered anatomical variations that may or may not be responsible for migraine headaches in some patients. What is known is that surgical decompression of these nerves has led to successful outcomes in terms of amelioration or complete elimination of migraine headaches in these patients whose treatment was guided by chemodenervation of the muscles surrounding these nerves.[26] What is important to investigate, though, is not only the successful treatments, but more importantly, the failures. If "diagnostic chemodenervation" was successful in the temporary amelioration of the migraine but the surgical decompression was not, it can be assumed that there has been an incomplete release of the nerve. Therefore, this study was designed to elucidate further the anatomy of the zygomaticotemporal nerve to determine whether anatomical variations in its course from its exit from its foramen through to

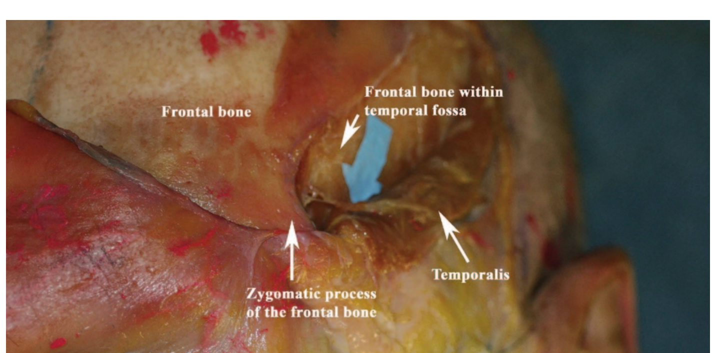

Fig. 3. The hemiface shown in Figure 2, with flap pulled down, revealing the zygomaticotemporal branch (*blue arrow*) taking a long intramuscular course.

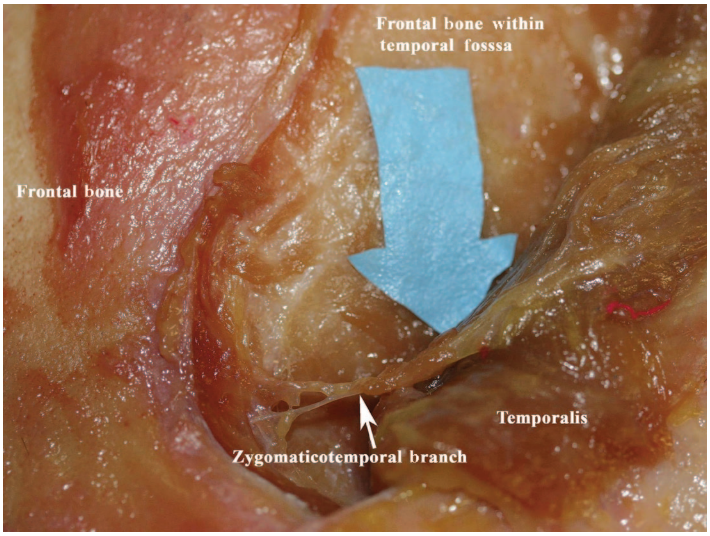

Fig. 4. Close-up view of the hemiface shown in Figure 3.

its superficial/distal extent could explain nonresponders to current surgical treatment.

In this anatomical dissection study of 50 cadaveric hemiheads, it was found that the zygomaticotemporal branch of the trigeminal nerve has a variable course, number of branches, and foramina. In 50 percent of the facial halves investigated, the nerve took an intramuscular course from its foramen in the lateral orbital wall to its exit from the deep temporal fascia; in the other half, the nerve exited the periorbital fascia and entered the temporalis fascia without entering the temporalis muscle (Fig. 5). Contrary to what is typically illustrated, it was seen that the zygomaticotemporal nerve foramen is not on the surface of the lateral orbit, but posterolateral to the edge of the lateral orbital rim (Figs. 6 through 8).

These anatomical discoveries are important, because they may explain some clinical findings. That the zygomaticotemporal branch of the trigeminal nerve takes an intramuscular course half the time shows that the path through the temporalis may potentially be a site of entrapment. If a patient has the temple as a trigger region for their migraine headaches, and the nerve entry or exit from the muscle is not decompressed, this may result in no relief. It could be possible that in those patients where there is an intramuscular course, or even more specifically a long/tortuous intramuscular course, that these patients are more prone/

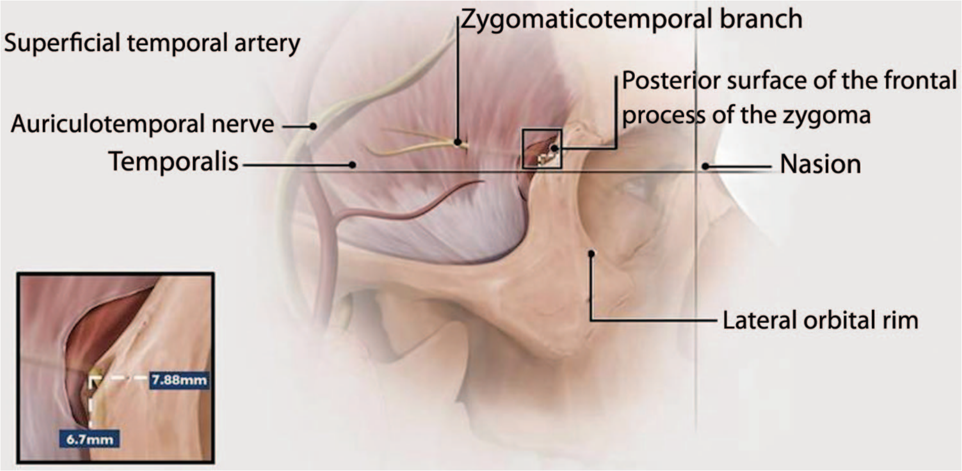

Fig. 5. Illustrations depicting the zygomaticotemporal branch of the trigeminal nerve taking an intramuscular course after it exits from its foramen.

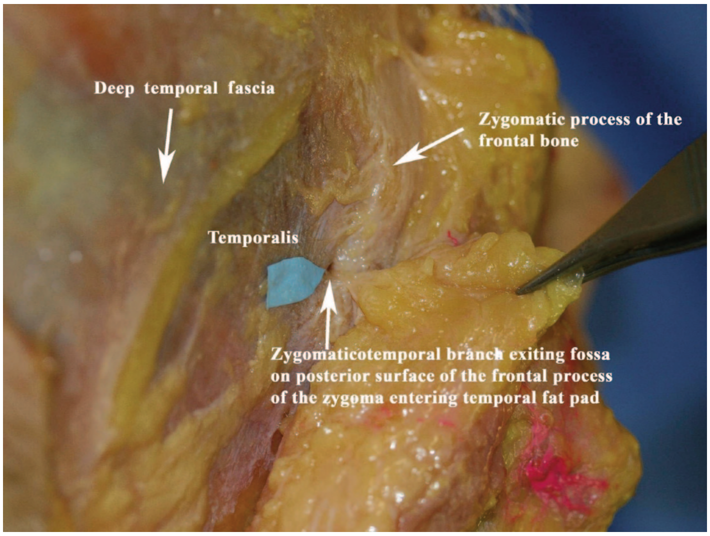

Fig. 6. Image demonstrating the zygomaticotemporal branch of the trigeminal nerve exiting the anterior portion of the temporal fossa behind the frontal process of the zygomatic bone. In this hemiface, the branch exits through the foramen in the zygomatic bone, travels between the periosteum and the bone, and then exits directly into the temporal fat pad between the deep temporal fascia and the temporoparietal fascia.

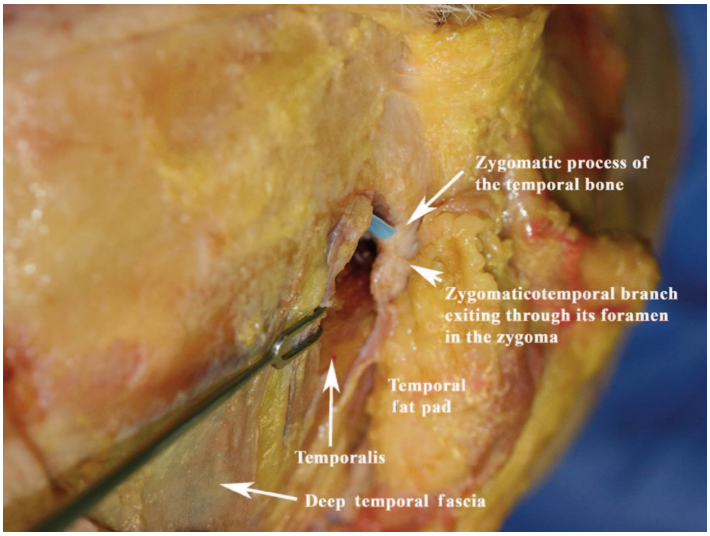

Fig. 7. View from above the temporal fossa demonstrating the anatomy of the zygomaticotemporal branch as it exits from its foramen, traveling behind the frontal process of the zygoma, and its relationship to the temporalis muscle, the deep temporal fascia, and the zygomatic process of the frontal bone. In this hemiface, the branch takes an extramuscular course.

susceptible to migraines compared with those with no intramuscular course or a short course. It would be interesting to somehow corroborate the incidence of migraine headache patients with a primary genesis of pain in the temple region with the incidences described in this study. Further study to examine for clinical correlations is currently under way.

One of the most debilitating complications is diplopia after botulinum toxin type A injection

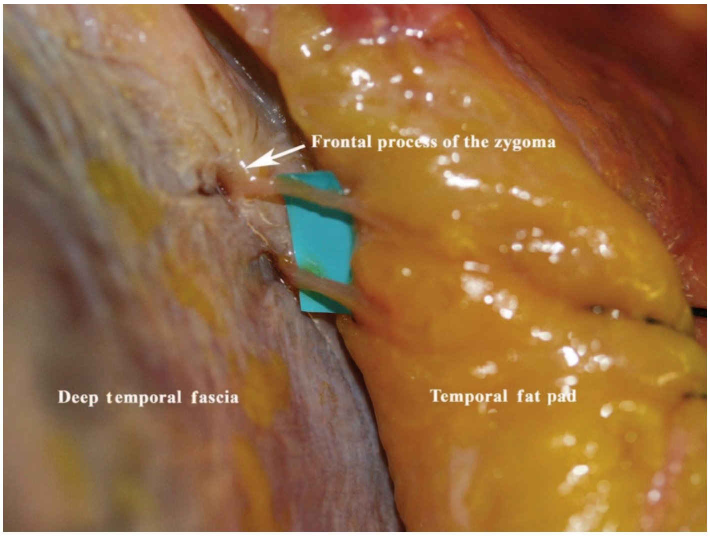

Fig. 8. View from above and posterior to the temporal fossa. Dissection in this hemiface revealed two branches, both taking extramuscular courses. Note tight fascial encasements of the nerve, between the periosteum overlying the zygoma and the deep temporal fascia.

which, based on physical examination and ophthalmologic consultation, was in fact weakening or paralysis of the ipsilateral lateral rectus extraocular muscle. Anecdotally, this has been seen in three patients by one of the senior authors (J.E.J.). Although the effects of this were temporary, it was extremely debilitating to the patients for the duration of their symptoms, which ranged from 6 weeks to almost 3 months. It is believed that the reason for this complication was inadvertent infiltration of the botulinum toxin through the foramina of the zygomaticotemporal branch of the trigeminal nerve. This is quite plausible, and this has been considered as a route of infection transmission previously.[22] Therefore, if we understood the anatomy of the zygomaticotemporal nerve better in this region, we could modify injection techniques to avoid this rare complication. Based on our findings, we believe that injection of botulinum toxin type A should be performed superficially into the temporalis muscle at a point well lateral to the lateral orbital rim.

Another important elucidation in this study was the presence of multiple branches of the zygomaticotemporal nerve. This is important to note to aid in more complete surgical decompression (avulsion) of this particular trigger point. Perhaps some of the failures could be attributed to incompletely addressing the nerve(s) in this area, much like incomplete carpal tunnel release of the median nerve, or even incomplete corrugator resection in the frontal trigger point group—this point has been shown by recent anatomical studies that demonstrated that the true dimensions of the corrugator supercilii muscle were previously underestimated.[27,28]

CONCLUSIONS

Combining the results of this study and previous anatomical work, the course of the zygomaticotemporal branch of the trigeminal nerve from its branch point off of the zygomatic nerve within the zygomatic bone, through the orbital region, into the temporal fossa, to finally arborize above the deep temporal fascia, is now fully understood. The nerve has three potential paths from the orbit to its exit from the deep temporal fascia: one that is long and intramuscular; another that is short and intramuscular; and finally, one that is completely extramuscular. It will be interesting to see whether the epidemiology of nonresponders to treatment corresponds with the frequencies of intramuscular courses uncovered in this investigation.

The results found in this study further our detailed understanding of the anatomy of the zygomaticotemporal branch of the trigeminal nerve. The elucidation of this anatomy is important to determine whether anatomical variations in its course from its exit from its foramen through its distal extent could explain nonresponders to current surgical treatment for migraine. It is also important to investigate complaints of treatment—not only unwanted side effects from attempts at chemodenervation, but also recurrence of migraine headaches, which we believe are likely to represent failures of surgical treatment because of inadequate decompression. Understanding the different potential compression sites will aid us in accurate diagnosis of where to focus clinical treatment. Further clinical study should enable us to achieve optimal surgical results.

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