The Current Means for Detection of Migraine Headache Trigger Sites

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Summary: The authors' 15-year experience with migraine surgery has led them to believe that the most common reasons for incomplete response are failure to detect all of the trigger sites or, on rare occasions, inadequate surgery on the trigger sites. Thus, accurate identification of trigger sites is essential. The purpose of this article is to share the authors' current stepwise algorithm for accurately detecting the migraine trigger sites, which has evolved through surgery on nearly 1000 patients. To begin, a thorough history is taken. Each patient's constellation of symptoms can point toward one or multiple trigger points. The patient is asked to point to the most frequent site from which migraine headaches originate with one fingertip, and then the site is explored with a Doppler. If an arterial Doppler signal is identified at the site, it is considered an active arterial trigger site. Response to a nerve block with a local anesthetic in a patient with an active migraine headache confirms the presence of a trigger site. If the patient does not have pain at the time of the office visit, an injection of botulinum toxin A at the suspected trigger site may be considered. Although positive responses to botulinum toxin A and nerve block are very helpful and reliable in confirming the trigger sites, negative responses must be interpreted with extreme caution. In patients with a migraine headache starting from the retrobulbar site, a computed tomography scan of the paranasal sinuses is obtained to look for contact points and other pathology that would confirm rhinogenic trigger sites. (*Plast. Reconstr. Surg.* 136: 860, 2015.)

Migraine headache is a common and often debilitating neurological condition. The senior author has developed a number of surgical techniques targeting sensory nerves in the head and neck that are thought to play a role in the initiation of migraine headaches. Several clinical studies have verified the efficacy and safety of these surgical techniques, which can result in significant improvement or elimination of migraine headaches in nearly 90 percent of patients, with minimal operative complications.[1–8]

Those surgical interventions target four major and several minor trigger sites (Fig. 1). The frontal trigger site (site I) involves the supraorbital and supratrochlear nerves, which are irritated by the glabellar muscles, the surrounding vessels, foramina, and fascial bands. In the temporal trigger site (site II), the zygomaticotemporal branch of the trigeminal nerve is compressed by the temporalis muscle and the tight deep temporal fascia, or irritated by the accompanying vessels. In the rhinogenic trigger site (site III), contact points between the septum, turbinates and concha bullosa, or sinus inflammation can irritate the terminal branches of the trigeminal nerve, triggering migraine headaches. In the fourth major site (site IV), the greater and/or the third occipital nerves are irritated by the semispinalis capitis muscle, fascial bands, and/or the occipital artery. The minor trigger sites consist of the auriculotemporal nerve (site V), which can be irritated by branches of the superficial temporal

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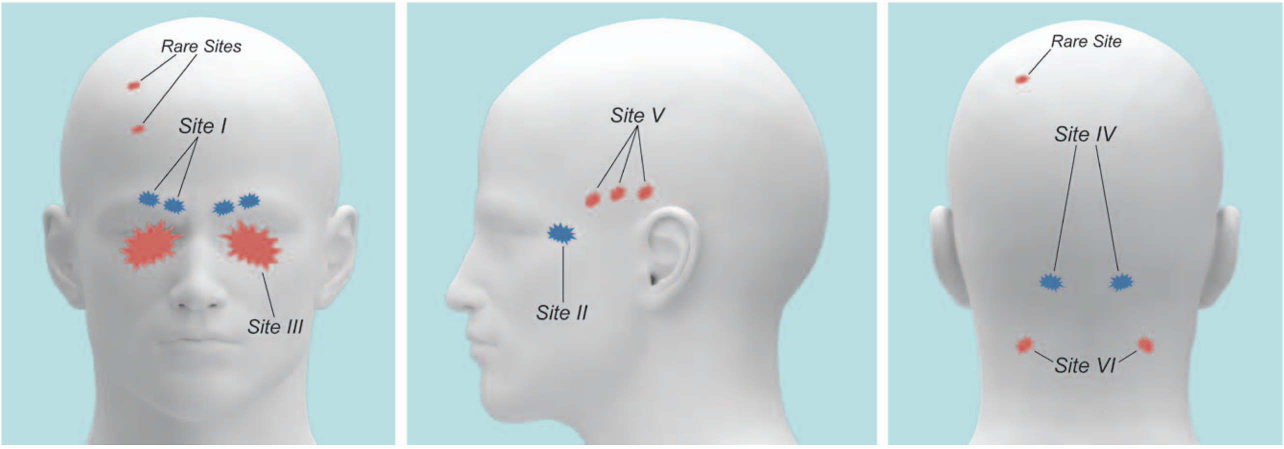

Fig. 1. Major and minor trigger sites.

artery and fascial bands, the lesser occipital nerve (site VI), which can similarly be compressed by fascial bands and the occipital artery branches, and terminal branches of each of these main nerves.

Despite its high efficacy, a small number of patients who undergo migraine surgery do not have improvement in their migraine headaches. This unfavorable response in some patients has been ascribed to incomplete detection of all of the trigger sites and inadequate decompression of the primary trigger point, which is rare.[7]

When a nerve has multiple compression or irritation points along its course, incomplete relief can be avoided by precise knowledge of the anatomy of the sensory nerves of the head and neck. The compression or irritation points of the frontal, temporal, occipital, and intranasal trigger points have been well described in several detailed anatomical studies.[9–20] The most common reason for failure of migraine surgery was the start of a migraine headache from a different trigger site, which perhaps was masked by the more dominant pain site.

A diagnostic algorithm based on botulinum toxin injection has been published previously.[4] With the discovery that not all compression points are muscular, and with the development of new diagnostic modalities, a broader algorithm is needed. The purpose of this article is to share with colleagues the most recent diagnostic modalities available for the proper identification of migraine trigger sites and present them in the form of a novel algorithm to further increase the success rate of this procedure.

TOOLS FOR PROPER IDENTIFICATION OF TRIGGER SITES

A diagnosis of migraine headache by a neurologist and a failure of conservative medical management are the typical requirements for selection of the proper surgical candidate. The next important step is to focus on identifying the sites from which the headaches originate, independent of the other sites. Where the migraine headaches extend and settle is not relevant to the surgery. It is crucial to question the patients repeatedly to ensure the consistency and accuracy of their responses.

MIGRAINE STARTING POINT

Most patients vaguely describe their pain originating from a specific region of the head and neck, independent of other trigger sites. With appropriate encouragement, they can often pinpoint the exact locus of the pain (Figs. 2 and 3). In the experience of the senior authors, patients have been able to pinpoint the location of migraine headache with utmost accuracy, confirmed by the Doppler signal and intraoperative evidence of involved musculature, vessels, bony foramen, or fascial bands. This is

Fig. 2. Identification of auriculotemporal trigger site.

Fig. 3. Identification of occipital trigger sites.

particularly important, for example, when attempting to distinguish between a zygomaticotemporal and an auriculotemporal trigger site, in which the patient's description of the location of the pain is the most helpful clue in differentiating between the two. The clinical history can even help differentiate between the different branches of the auriculotemporal nerve: the patient may experience pain along the main nerve that is stimulated by the superficial temporal artery, in which case the pain would commence close to the helix. Alternatively, the pain could be originating from the anterior branch of the nerve, in which case the patient will point to the area close to the anterior hairline (Fig. 2). The posterior branch of the zygomaticotemporal branch of the trigeminal could be the source of pain, whereby the headaches will be experienced posterior to the typical pain site for the main nerve. Similarly, the lesser occipital (site VI) pain will start near the occipital hairline closer to the ear, rather than where the greater occipital nerve exits from the semispinalis capitis muscle, which is 3.0 cm caudal to the occipital tuberosity and 1.5 cm lateral to the midline.[9,15] It is crucial to ask the patient to identify the autonomous trigger site with a fingertip several times and on different occasions, if possible, to ensure persistence and reliability.

CONSTELLATION OF SYMPTOMS

The constellation of symptoms of a given migraine patient is one of the simplest ways to identify a patient's trigger sites. This method is practical, fast, and has been shown to direct surgeons to the proper sites reliably. We have previously described the most common symptom patterns associated with each trigger site.[21,22]

Patients with a frontal trigger site (site I) have headaches that start from the supraorbital area independent of the other sites and typically occur in the afternoon (Table 1).[21] The pain is characteristically imploding in nature. These patients often have strong corrugator muscle activity causing deep frown lines on animation and even repose. In addition, the points of emergence of the supraorbital and supratrochlear nerves from the corrugator muscle or the foramen are tender to the touch. At the time of active pain, patients may exhibit eyebrow or eyelid ptosis on the affected side. Pressure at these sites may actually abort the migraine headache if it is done early enough. Application of cold or warm compresses at this site can also help reduce or stop the pain.

Patients with a temporal trigger site (site II) also experience an imploding type pain originating in the temporal region independent of other sites (Table 2),[21] approximately 17 mm lateral and 6 mm cephalad to the lateral canthus, correlating with the exit point of the zygomaticotemporal branch of the trigeminal nerve from the deep temporal fascia. Patients can often apply manual compression and cold or warm compresses to this site to abate the pain in the initial stages of their headache. These headaches typically occur in the morning, waking patients from their sleep. Patients or spouses may report bruxism during the night.

Table 1. Constellation of Symptoms Related to the Frontal Migraine Headache (Site I)*

The pain starts above the eyebrows.
The pain usually starts in the afternoon.
There is strong corrugator muscle activity causing deep frown lines on animation and repose.
The points of emergence of the supraorbital and supratrochlear nerves from the corrugator muscle or the foramen are tender to the touch.
Patients commonly have eyelid ptosis on the affected side at the time of active pain.
Pressure on these sites may abort the MH during the initial stages.
Application of cold or warm compresses on these sites often reduces or stops the pain.
The pain is usually imploding in nature.
Stress often can result in triggering the MH.

MH, migraine headache.
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Table 2. Constellation of Symptoms Related to the Temporal Migraine Headache (Site II)*

The pain starts in the temple area approximately 17 mm lateral and 6 mm cephalad to the lateral canthus.
Patients usually wake up in the morning with pain after clenching or grinding their teeth all night.
Often, the pain is associated with tenderness of the temporalis or masseteric muscle.
One may see wearing of the dental facets.
Rubbing or pressing the exit point of the zygomaticotemporal branch of the trigeminal nerve from the deep temporal fascia can stop or reduce the pain in the beginning.
Application of cold or warm compresses to this point may reduce or stop the pain.
The pain is characterized as imploding.
Stress can trigger MH in this site.

MH, migraine headache.
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Table 3. Constellation of Symptoms Related to the Rhinogenic Migraine Headache (Site III)*

The pain starts behind the eye.
Patient commonly wakes up with the pain in the morning or at night.
Commonly, the MH is triggered by weather changes.
Rhinorrhea can accompany the pain on the affected side.
This type of MH can be related to the nasal allergy episodes.
Menstrual cycles can trigger MH.
The pain is usually described as exploding.
Concha bullosa, septal deviation with contact between the turbinates and the septum, septa bullosa, and Haller's cell can be seen on the CT scan.

MH, migraine headache; CT, computed tomographic.
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Table 4. Constellation of Symptoms Related to the Occipital Migraine Headache (Site IV)*

The pain starts at the point of exit of the greater occipital nerve from the semispinalis capitis muscle (3.5 cm caudal to the occipital tuberosity and 1.5 cm off the midline).
There is no specific starting time for the pain.
The patients may have a history of whip-lash.
The neck muscles are usually tight.
Heavy exercise can trigger the MH.
Compression of this site can stop the pain in the early stage, whereas at the later stage, the point is tender.
Application of cold or heat at this site may result in some improvement in the pain.
Stress can be a trigger for occipital MH.

MH, migraine headache.
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Rhinogenic migraine headache (site III) patients classically experience an exploding type pain originating behind the eye, independent of other trigger sites, typically in the early mornings (Table 3).[21] The headaches can awaken the patient in the middle of the night, and assumption of erect position may reduce the pain. Low atmospheric pressure, menstrual periods, and supine positions may trigger headaches by causing engorgement of the turbinates and increasing the intensity of the contact between the turbinates and the septum. In addition, because rhinogenic migraine headaches are typically the result of contact points between the septum, turbinates, and concha bullosa, decongestants can be used to reduce edema of these structures, which often alleviate or diminish these headaches.

Patients with occipital migraine headache (site IV) typically experience pain starting in the upper neck and occipital region at the point of exit of the greater occipital nerve from the semispinalis muscle (Table 4),[21] independent of the other pain sites. Manual compression of this site at the early stages of the migraine can assuage the pain, whereas at later stages, this point becomes tender. These patients' headaches may be triggered by stress or strenuous exercise. Patients can exhibit muscle tightness in the region. In addition, a history of whiplash or neck sprain may be present.

We previously compared the outcomes of migraine surgery on patients whose trigger sites were detected using constellation of symptoms with those who receive stated injection of botulinum toxin A. We determined that there was no statistical difference in outcomes between the two groups, demonstrating that constellation of symptoms alone is a viable diagnostic option.[21]

DOPPLER SIGNAL

Several of the nerves implicated in migraine headache pathogenesis may intersect with an artery, including the supraorbital and supratrochlear nerves and their branches, the auriculotemporal nerve and its branches, the zygomaticotemporal nerve and its branches, the greater occipital nerve, the lesser occipital nerve, and even the zygomaticofacial nerve. Patients who have such an intersection may complain of pulsatile, throbbing headache.[16] The use of the handheld Doppler in clinic, as part of the physical examination, has proven to be an extremely useful tool in identification of trigger points where an artery is irritating the nerve (Fig. 4).[23] The Doppler is able to pick up an arterial signal at the location of pain identified by the patient with near-perfect accuracy.

We demonstrated that the auriculotemporal nerve intersects with the superficial temporal artery in 34 percent of individuals.[18] In most instances, this is a single-point intersection, but in a minority of individuals, it may consist of a helical intertwining. Auriculotemporal trigger site is an entity that was often undiagnosed in the early years of migraine surgery. Janis et al. uncovered auriculotemporal pain in two patients after decompressing the zygomaticotemporal nerve.[6]

The greater occipital nerve intersects with the occipital artery in 54 percent of individuals.[15] This intersection consists of a helical intertwining between the two structures in a majority of cases, with the remainder having a simple intersection. This intersection point is located 1 mm to 25 mm inferior to the external occipital protuberance and 25 mm to 42 mm lateral to the midline.

The lesser occipital nerve intersects with the occipital artery branches in 55 percent of individuals, usually as a simple intersection.[19] This intersection point is located 16 mm to 22 mm caudal to the anterosuperior external auditory canal, and 51 mm to 52 mm lateral to the midline.

The Doppler has been very useful in detecting the rare sites, such as the superior portion of the forehead, as well as various unusual sites in the temple and vertex. Invariably, a signal has been identified where the patient points to the most tender spot in each of the rare trigger sites. The correlation between the location of the patient's pain and the presence of a vessel has been enormously fascinating and gives us great insight and further evidence to support the pathology of nearby vasculature causing nerve irritation and migraine headaches at some specific sites.

NERVE BLOCK

When a patient is seen in the office during a migraine attack, there is a superb opportunity to do a nerve block to confirm the suspected trigger site. The patient is asked to point to the site of maximal tenderness from which the headache seems to be originating with a fingertip. One half to 2 cc of ropivacaine is then injected into this point using a 30-gauge, half-inch-long needle for most sites, except for the greater occipital nerve block, where a 1-inch-long needle is preferred. Migraine relief after 5 to 10 minutes identifies the trigger site reliably. Local anesthetic nerve block is immediate and especially practical for out-of-town patients, who are unable to comply with the botulinum toxin A injection schedule. However, in order to have a meaningful interpretation of

Fig. 4. Use of Doppler at temporal trigger site.

the results, the patient must have some pain at the trigger site. In addition, when the entire trigeminal tree is inflamed, the nerve block may cause localized numbness without eliminating the migraine headache. Therefore, whereas a positive response is extremely helpful, the lack of response or an inadequate response should be interpreted with caution and does not necessarily rule out the trigger point in question.

Unlike botulinum toxin, response to the blocks is not specific to a particular type of nerve compression. Rather, it can help identify muscular, fascial, bony, or arterial compression. For example, a patient who does not respond to botulinum toxin but does respond to a diagnostic nerve block can be assumed to have nonmuscular nerve compression or irritation of the nerve.

BOTULINUM TOXIN A INJECTION

The discovery of migraine surgery coincided with studies reporting the efficacy of botulinum toxin A injection for the treatment of migraine headache in the neurology literature,[24,25] the most important of which was the PREEMPT-2 trial.[26]

We introduced the anatomic injection of botulinum toxin A into specific muscular compression sites of the sensory nerves of the head and neck that are involved in the pathogenesis of migraine headaches.[2] Early on, a diagnostic algorithm of sequential botulinum toxin A injections was used to help detect and confirm suspected trigger sites in patients before surgery.

Patients with an occipital trigger site typically receive 25 units per side, injected into the semispinalis muscle in the vicinity of emergence of the greater occipital nerve (3 cm inferior to the occipital protuberance and 1.5 cm lateral to the midline) on each side.[9,15] Patients with a frontal trigger site typically receive 12.5 units per side, injected into the glabellar musculature. Patients with a temporal trigger site receive 25 units per side, injected into the temporalis muscle in a fan shape starting near the point of emergence of the zygomaticotemporal nerve (17 mm lateral and 6.5 mm superior to the lateral ocular commissure).[14]

We now know that there are nerve compression or irritation sites that are nonmuscular. Several anatomic studies have examined the supraorbital foramen and the notch and fascial bands as potential compression points of the supraorbital and supratrochlear nerves.[17,27] Such bony/fascial compression points would not respond to botulinum toxin A injection, but they could be detected with nerve block, confirmed with computed tomography scan, and benefit from foraminotomy or fascial band release. At the temporal trigger site, we demonstrated that the zygomaticotemporal nerve travels through the temporalis muscle in 50 percent of individuals, but in the remaining 50 percent, it pierces the deep temporal fascia without traveling through the muscle.[14] Other nonmuscular compression points include the intersection of the auriculotemporal nerve with the superficial temporal artery,[18,28] and the intersection of the greater occipital nerve with the occipital artery.[15] Therefore, although reliable in most cases, especially when the response is positive, botulinum toxin A is not always practical. When the botulinum toxin A injection results in reduction of the frontal migraine headache's intensity without elimination or change in frequency, it may mean that the positive response was the consequence of reduction in secondary irritation of the supraorbital and supratrochlear branches by the dynamic effects of the glabellar muscle, whereby the primary irritation commences from the nasal cavity.

Other barriers to the use of botulinum toxin A include potential lack of insurance coverage, as well as the length of time and the multiple visits required for detection of migraine headache on a patient with multiple trigger sites. In addition, frontal procedures are delayed at least 3 months after injection of botulinum toxin A because it results in the atrophy and pale discoloration of the muscle, which renders its adequate removal extremely difficult. However, a positive botulinum toxin A response has been shown to be a prognosticator of migraine surgery success.[29]

If botulinum toxin A is used for detection of the trigger site on a patient who lives locally, the most common and severe migraine headache starting site is injected first. The patient's subsequent trigger sites (maximum of three) are injected using our published algorithm, spaced 1 month apart to confirm any additional trigger sites.[4,30] For patients who live out of town, all the trigger sites from which the headaches start independently are injected with botulinum toxin A during the initial visit to avoid multiple trips. The response is then analyzed at each site independently. When botulinum toxin A injection fails, the use of Doppler and local anesthetic blocks become invaluable tools to detect trigger sites as long as the patient has pain at the time of injection.[31]

COMPUTED TOMOGRAPHY SCAN

In the case of rhinogenic (site III) migraine headaches, the computed tomography scan is an indispensable tool. The presence of contact points on computed tomography scan between the septum, turbinates, concha bullosa, paradoxical curl of the turbinates, Haller's cell, and inflammation of the sinus lining are almost diagnostic of a rhinogenic trigger site.[32] In combination with a careful history and physical examination, computed tomography helps the surgeon to identify the specific intranasal abnormalities to be addressed surgically.

An emerging use of computed tomography is in the preoperative identification of bony compression sites in frontal migraine headache patients.[33] Janis et al. demonstrated that the supratrochlear nerve travels through a frontal notch in 76 percent of individuals and in a bony foramen in 18 percent.[17] We demonstrated that thin coronal and sagittal views using perinasal sinus computed tomography may show the presence of a supraorbital or frontal foramen, especially in a patient with a frontal trigger site who did not respond to botulinum toxin A injection.[33]

SUMMARY AND FUTURE DIRECTION

Beyond confirmation of migraine headaches by a neurologist, the accurate detection of migraine headache trigger sites is the most important step in safe and successful migraine surgery. This has been a process of evolution and learning from the outcomes, listening to patient statements, anatomical studies,[9–20] and ancillary tests. Use of Doppler to confirm the trigger sites in recent years has been a tremendous development that intrigues us on daily basis. An additional incentive for use of Doppler is patient participation. Listening to the Doppler sound at the location the patient pointed to and/or observing computed tomography findings together allows patients to observe and understand some of the elements contributing to their migraine headaches without prior medical knowledge. Furthermore, use of these objective findings reduces speculation and is more comforting for the entire team.

It is our conviction that the most common reason for an incomplete or poor response to surgery is the failure to detect all of the appropriate trigger sites. Knowledge of all available diagnostic modalities, and application of those modalities in a logical, stepwise algorithm, can help avoid such errors and allow the migraine surgeon to develop a reliable, individualized surgical plan for each patient, with the aim of addressing all necessary trigger points in one surgical setting.

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PATIENT CONSENT

The patient provided written consent for the use of her images.

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