
Views and Perspectives

A Critical Evaluation of Migraine Trigger Site Deactivation Surgery

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Migraine headache trigger site deactivation surgery is a term that encompasses 4 different surgical procedures that are performed based on headache onset location for the preventative treatment of migraine headaches. Multiple studies have demonstrated some efficacy of these procedures, but closer evaluation of the methodology of these studies reveals major flaws in study design. In this article, the author provides an overview of the procedures and presurgical screening tools, as well as a critical evaluation of 2 of the major studies that have been published. In addition, the author provides his opinion on future study designs that may help to better determine the potential efficacy of these experimental procedures and potential headache subtypes (contact point headache, supraorbital neuralgia, and occipital neuralgia) that may respond to peripheral decompression surgery.

Key words: migraine headache trigger site deactivation surgery, migraine surgery, contact point headache, supraorbital neuralgia, occipital neuralgia, cranial neuralgia

(*Headache* 2013;••:••-••)

Migraine is the most common primary headache disorder for which patients present for evaluation and treatment. In US population studies, the prevalence of migraine is estimated to be 18% in women and 6% in men.¹⁻³

Migraine preventative pharmacologic treatments span several different classes, including beta blockers (propranolol, atenolol, nadolol, metoprolol, timolol), calcium-channel blockers (verapamil), anticonvulsants (topiramate, divalproex sodium,

gabapentin), tricyclic antidepressants (amitriptyline, nortriptyline, protriptyline), and neurotoxins like onabotulinum toxin type A (BTX). The use of these preventative medications is often limited by contraindications, side effects, and lack of efficacy.⁴ In a survey study involving 1165 subjects, 28.3% with episodic migraine (EM) and 44.8% with chronic migraine (CM) were currently using preventive medication, and 43.4% with EM and 65.9% with CM had ever used a preventative medication. The mean number of preventative medications ever used was 2.92 for EM and 3.94 for CM. Based on this study, less than half of migraine sufferers are currently using preventative treatment, and medication discontinuation is prevalent for unclear reasons.⁵

Given the high prevalence of migraine and inconsistent effectiveness of preventative treatment, a plastic surgeon, Bahman Guyuron, MD, devised 4 surgical procedures intended to “deactivate migraine

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Accepted for publication August 9, 2013.

Conflict of Interest: The author reports no conflicts of interest.

headache trigger sites.”⁶ The theory behind these procedures is that peripheral nerve compression in the head and neck can serve as a migraine trigger. BTX injections may serve to transiently relieve this hypothetical nerve compression through adjacent muscle relaxation, and surgical resection of compressing adjacent structures may potentially accomplish the same task.

SURGICAL PROCEDURES

These procedures are performed based on headache onset location.

For patients whose headaches have an intranasal origin, septoplasty and turbinectomy are performed.

For patients whose headaches start in the frontal region, an upper eyelid incision is made in order to remove the corrugator supercilii, depressor supercilii, and procerus. A small amount of fat from the upper eyelid is used to fill the area occupied by the excised muscles, and to shield the preserved supraorbital and supratrochlear nerves.

For patients whose headaches start in the temporal region, two 1.5 cm incisions are made in the temples, and a segment of the zygomaticotemporal branch of the trigeminal nerve is resected. At times, segments as long as 3 cm are removed.

For patients whose headaches start in the occiput, a 4 cm midline occipital incision is made in order to resect a 1 cm × 2.5 cm portion of the semispinalis capitis muscle that is medial to the greater occipital nerve. The nerve is then shielded using a subcutaneous flap to isolate it from surrounding muscles. If there is contact between the occipital artery and occipital nerves, the artery is at times also resected.^{6,7}

From a strictly procedural analysis standpoint, if the theory behind these procedures is that nerve compression is serving as a trigger for migraines, it is unclear why branches of the trigeminal nerve are being resected rather than decompressed for patients whose headaches start in the temporal region. Based on the trigeminal neuralgia literature, it is clear that procedures that involve damaging or destroying a peripheral nerve can lead to numbness, paresthesias, dysesthesias, and even worsening of preoperative pain.^{8,9}

PRESURGICAL EVALUATION AND SCREENING TOOLS

Physical Examination.—As part of the presurgical evaluation, a physical examination including palpation of the potential surgical site is performed. For patients with an intranasal trigger zone, an intranasal examination is performed to look for abnormalities such as a deviated septum or enlarged turbinates.

Injectable Screening Tools.—As part of the surgical evaluation, BTX injections (25 units) or nerve blocks are performed in the frontal, temporal, or occipital region based on the location of headache onset as a screening tool to help determine surgical candidates,⁷ but such screening tools are flawed from a functional standpoint. It is important to note that not all surgeons use either of these modalities for screening purposes, and some surgeons may proceed with surgery even if neither of these screening tools yields positive outcomes.

BTX injections inhibit the release of acetylcholine, leading to chemical denervation and muscle paralysis. Although this paralysis could theoretically transiently alleviate suspected nerve compression, BTX is likely effective for the treatment of migraines through other mechanisms as well, which would create false positive indicators for surgical screening purposes.

BTX blocks the transmission of γ -motor neurons to the muscle spindles, which relay afferent muscle stretch information to the central nervous system. This reduced transmission may decrease hyperactive muscle contractions resulting in a reduction of pain.¹⁰⁻¹³ In addition, BTX affects some nerve terminals that contain substance P, calcitonin gene-related peptide, somatostatin, enkephalins, norepinephrine, adenosine triphosphate, neuropeptide Y, and nitric oxide,¹³⁻¹⁵ which play varying roles in the pathophysiology of migraine.

In one plastic surgery study, it has been noted that utilizing Botox injections to confirm trigger sites does not improve the outcome of migraine surgery. This study was a chart review study that involved 335 migraine surgery patients. Two hundred forty-five subjects received stepwise diagnostic injections of BTX, and 90 subjects in the control group received no BTX or only therapeutic BTX.

It is unclear what is implied by therapeutic BTX, and why any patients in the control group received any BTX. In the review, there is no mention of how many units were utilized. The injections were performed at the sites deemed by the evaluating surgeon to be migraine trigger sites.

The preoperative and 12-month postoperative migraine headache frequency, duration, and intensity were compared to determine the success of the operations. Seventy-two of 90 control subjects experienced a decrease of at least 50% in migraine headache frequency, duration, or intensity at 12 months after surgery. Twenty-nine of 90 control subjects reported complete elimination. Of the 245 in the BTX group, 207 experienced a decrease of at least 50% in migraine headache frequency, duration, or intensity at 12 months after surgery. Of the 245 in the BTX group, 89 experienced complete elimination. It is unclear whether the term complete elimination is referring to just migraine or all types of headache. The surgical success rate of the BTX group was not significantly higher than that of the control group.¹⁶

In clinical practice, it is unclear why patients who respond to 25 units of BTX proceed to surgery, rather than receiving higher doses of BTX. According to the Phase III REsearch Evaluating Migraine Prophylaxis Therapy 2 Trial (PREEMPT-2), which was a phase 3, double-blind, placebo-controlled trial addressing the use of BTX for chronic migraine, 155-195 units of BTX was found to be effective for the prophylaxis of headache in adults with chronic migraine. Repeated BTX treatments were found to be safe and well tolerated.¹⁷ In addition, many of the subjects in migraine surgical studies had episodic migraine, and it has been demonstrated that BTX is not effective for the treatment of episodic migraine.¹⁸

Although peripheral nerve blocks target peripheral nerves, these procedures likely also have effects on central pain modulating structures. For example, studies have demonstrated that after performing occipital nerve blocks, migraine pain, brush allodynia in the trigeminal nerve distribution, and photophobia tend to improve.¹⁹ These data suggest that peripheral nerve blocks may modulate pain transmission at peripheral and central targets. Thus, using peripheral nerve blocks as a confirmation of nerve compression

would potentially create false positives when used as a migraine surgery screening tool. In clinical practice, nerve blocks can also at times be utilized for headache prophylaxis.²⁰

The practice of making a decision to proceed with migraine surgery based on such nonspecific screening tests as BTX injections or nerve blocks would be like a spine surgeon using lidocaine patches as a screening tool for low back pain, and proceeding with a laminectomy in patients who responded positively to lidocaine patches. Although a laminectomy may treat certain types of back pain, it is an invasive surgery that should only be performed after specific diagnostic studies have been performed that establish a clear surgical target.

Although failure of best medical management is most often a prerequisite for surgery, additional/higher doses of BTX or serial nerve blocks are likely not utilized in clinical practice due to patient access, patient awareness, or awareness of these modalities on the part of the patient's nonsurgical providers (primary care provider, neurologist, or other non-headache specialists). It is questionable whether the surgeon performing migraine surgical procedures would offer or recommend either standard doses of BTX or serial nerve blocks, as improvement of the headache with these modalities would likely deter patients from proceeding with surgery.

Imaging Studies.—The only imaging study that is routinely noted in the surgical literature as part of a presurgical evaluation is a CT scan of the sinuses to confirm intranasal pathology in patients who were being evaluated for deactivation of intranasal trigger sites.⁶ Although septal deviation and enlarged turbinates are the primary pathologies that were being evaluated with these scans with the intention to proceed with septoplasty and/or turbinectomy, it is unclear whether there was any additional focus of attention to look for contact points between the lateral nasal wall and the septum. Such contact points when present could be causing intranasal contact point headache, which is a separate entity from migraine, and can be responsive to surgical treatment according to the literature.^{21,22}

In the case of deactivation of migraine headache trigger sites in the frontal, temporal, and occipital trigger sites, a potential imaging screening tool could

be high-resolution three-dimensional MRI imaging through the course of the supraorbital, supratrochlear, greater occipital, and/or lesser occipital nerves to look for evidence of nerve compression. Such imaging techniques are utilized to examine the course of the trigeminal nerve for evaluation of trigeminal neuralgia, and clear evidence of vascular compression has been demonstrated with high reliability based on intraoperative confirmation during microvascular decompression surgery.²³ Ultrasound has also been utilized to visualize the course of cranial peripheral nerves to look for compression.²⁴

Future studies may clarify if such imaging techniques could be applied to supraorbital, supratrochlear, and greater/lesser occipital nerves to demonstrate a clear surgical target in the context of patients with an isolated neuralgia with or without migraine that has been refractory to medical management.

GUYURON'S PLACEBO CONTROLLED TRIAL⁷

To date, there has only been a single placebo controlled surgical trial for the evaluation of migraine headache trigger site deactivation.

Design and Methods.—Initially, 317 subjects were screened, but only 130 subjects proceeded with BTX screening treatment with 25 units in the frontal, temporal, or occipital trigger sites based on where their headaches originated. In the manuscript, there is no indication why less than 50% of the subjects screened were included in the study. Surgery was only performed after the therapeutic benefit of BTX concluded.

Of the 130 subjects, 76 were deemed eligible for the study based on their response to screening BTX injections with a 50% reduction in one of the following: frequency, intensity based on a visual analogue scale,¹⁻¹⁰ duration in days, or migraine headache index. The migraine headache index is a number that is a product of following formula: (frequency X intensity X duration).

Of the 76 subjects, 49 received actual surgery, and 26 received sham surgery. In the manuscript, there is no indication why the intervention group was nearly double the size of the control group. There is no

mention of whether these groups were balanced. There is also no mention as to whether these patients were taking preventative medications or abortive medications during the study. As one could imagine, the introduction of an effective preventative treatment or abortive treatment at any time during the trial could cause a 50% reduction in headache frequency, intensity, or duration of the headaches. For example, if a new triptan is introduced during the postsurgical phase, and headache duration improves from 4 hours to 2 hours, this would be considered a positive surgical outcome. The use of the migraine headache index could further distort what is considered a positive outcome. For example, if a patient experiences a 17% reduction of migraine frequency, intensity, and duration, a greater 50% reduction in migraine headache index is achieved, which would again indicate a positive surgical outcome.

The baseline headache frequency of the subjects in the intervention group was 9.9 ± 6.0 migraine headaches per month and 9.5 ± 4.4 migraine headaches per month in the control group. These numbers would suggest that the overwhelming majority of patients had episodic migraine. As such, a reduction of 1-2 migraine headache days per month could be a surgical success by the author's criteria since it would be a 50% reduction in frequency for some of the subjects. In addition, the vague terminology of migraine headaches per month does not specify whether these reported numbers represent headaches or days per month, and they also do not specify whether non-migraine headache days are included. Non-migraine headaches in the setting of a subject that has migraines are included in the Revised International Headache Society Criteria for Chronic Migraine, and can contribute significantly to suffering.²⁵ The concept of only including migraine headache days also opens the possibility that some patients in the study experienced a worsening of their total headache days per month, but not migraine headache frequency. For example, a patient with episodic migraine who averages 6 total headache days per month, which are all disabling migraines, could potentially have a postoperative outcome of having 25 total headache days per month with only 3 migraine headache days per month (a net increase in headache with 22 non-migraine

headache days per month). This by the author's definition would be a positive outcome, as there has been a 50% reduction in migraine headache frequency per month. In addition, postoperative pain may not be considered headache by the subject or the evaluator, and these data could possibly have been omitted.

The subjects had follow-up evaluations at 3, 6, 9, and 12 months after surgery, but there is no mention of who is performing these evaluations during the double-blind phase of the trial. Ideally, these evaluations should have been performed by independent neurologists.

Intervention.—The intervention group received the procedures detailed above based on their trigger sites. The frontal headache sham group received an upper eyelid incision to expose the muscles and nerves, but there was no resection of these structures. The temporal headache sham group received two 1.5-cm incisions in the temple, but the nerve was left intact. The occipital headache sham group received a 4-cm midline occipital incision to expose the nerve, but the muscle was left intact. Although all subjects were blinded as to which intervention they received, the retained movement of the corrugator supercilii, depressor supercilii, and procerus muscles in the sham group likely led to subjects in the sham group becoming aware that they received the sham procedure. In addition, it is assumed that the subjects in the frontal group received bilateral surgery for cosmetic reasons, but it is unclear whether subjects received bilateral or unilateral surgery in the temporal and occipital groups. This also draws into question whether bilateral or unilateral procedures are performed in clinical practice for patients with a unilateral headache origin.

Results.—Of the 49 subjects who underwent the actual intervention, 28 reported complete elimination of “migraine headaches,” and 41 reported “significant improvement” at 12 months. Of the 26 subjects who received sham surgery, 1 reported complete elimination of “migraine headaches,” and 15 reported “significant improvement.” This terminology again may not reflect the non-migraine headaches appreciated by these subjects. In addition, there is no mention of any new abortive or preventative medication changes that may have been instituted during the follow-up

period. In my clinical practice, there are patients who have adjusted their medications or resumed BTX injections after surgery due to continued headache with improvement of their headaches. This improvement would then potentially artificially improve the surgeon's postoperative statistics.

Adverse Events.—In terms of adverse events, subjects experienced variable complications based on the site of the surgical intervention. In the frontal group ($n = 19$), 1 subject had persistent forehead numbness (1 year postoperatively), 1 subject had asymmetric eyebrow elevation, and 1 subject appreciated residual function of the corrugator supercilii. In the temporal group ($n = 19$), 10 subjects experienced temporal hollowing, 2 subjects experienced intense pruritis, and 1 subject experienced temporal hair loss/thinning. In the occipital group ($n = 11$), 1 patient experienced neck stiffness (1 year postoperatively). Interestingly, only 2 of the adverse events were specifically cited to last for greater than 1 year, which would lead some readers to assume that the other events lasted for less than 1 year and resolved when in fact some of these adverse events may actually be ongoing. Other complications of the intervention noted in the literature include cutaneous hypersensitivity, neck weakness, and facial nerve injury.⁶

Author's Conclusions.—The author attributes some of the improvement in the sham surgery group at 1 year after surgery to the placebo effect. To expand on the power of sham procedures, the author references a sham intervention placebo effect noted in an acupuncture trial involving 37 subjects who received either 16 real or sham acupuncture treatments over 3 months. These subjects experienced similar reductions in migraine frequency regardless of receiving sham or actual acupuncture.²⁶ It is interesting that the author references a sham procedure placebo effect for acupuncture, which has weak evidence for migraine prevention, to support the high placebo effect for another procedure with weak evidence such as surgical deactivation of migraine headache trigger sites.

The author also suggests that the subjects in the sham surgery group provided exaggerated preoperative data to increase their chance of selection, which would also improve outcomes in the placebo group.

This is a great argument to nullify any control group in any study if there is gain to be made by promoting the actual intervention.

The author then attempts to oversimplify and discredit the trigeminovascular theory of migraine by claiming that the literature is unclear whether migraines are caused by cortical neuronal hyperexcitability, cortical spreading depression, peripheral activation/sensitization, central activation/sensitization, abnormal modulation of brain nociceptive systems due to dysfunction of the periaqueductal gray matter, or changes in the meningeal vasculature.⁷ The reality is that these different mechanisms that the author attempts to single out as a potential cause of migraine are likely different events that occur in sequence leading up to a migraine.

Migraine is a complex genetic disorder with susceptibility likely arising from one or more variants in the genetic code. Recent models of migraine are centered on the trigeminovascular theory in which vascular changes occur as a result of neuronal activity. The term cortical spreading depression (CSD) was coined by Leao to describe the neuronal hyperexcitation followed by suppression that is observed to move across areas of contiguous cortex.²⁷ CSD likely accounts for the gradual progression and regression that occurs with migraine visual and sensory aura symptoms.²⁸ In cerebral blood flow studies, it was demonstrated that CSD is accompanied by a transient increase in blood flow followed by a transient reduction in cerebral blood flow which moved across neurovascular boundaries. CSD and the resulting vascular changes ultimately lead to activation of meningeal nociceptive neurons, second-order nociceptive neurons within the trigeminal nucleus caudalis, thalamus, periaqueductal gray matter, cortex, and other CNS structures, which lead to central sensitization of the trigeminal system.²⁹ This cascade of events leads to the disabling pain, photophobia, phonophobia, osmophobia, nausea, vomiting, and cutaneous allodynia associated with migraine.

Among the many weaknesses of this study, no subjects received the intranasal procedure or sham intranasal procedure, but benefit from this procedure is inferred throughout the surgical literature based on

the weak data from deactivating the frontal, temporal, and occipital trigger sites in the placebo controlled study.

GUYURON'S 5-YEAR OUTCOME STUDY⁶

This study is one of the most heavily cited studies in the surgical literature that supports migraine headache trigger site deactivation. Many of the weaknesses in the placebo controlled study are also present in this study.

Design and Methods.—One hundred twenty-five subjects were randomly assigned to a treatment group (n = 100) or a control group (n = 25). The treatment group received BTX injections to confirm their trigger sites, and the control group received saline injections. According to the manuscript, the control group sample size was selected by a biostatistician based on the results of previous studies. No additional details are provided regarding the size of the groups. The patients in the treatment group received BTX injections in a “logical, stepwise manner; the most prominent site was injected first to provide confirmation.” Up to 4 triggers sites were identified based on history, physical examination, and response to BTX. The control group received 0.5 mL of saline. In other words, this study compared a treatment group that received BTX treatment and then surgery with a control group that only received placebo injections with saline. This methodology is flawed in that the control group did not receive sham surgery, which would not qualify it to be a control group in a surgical study. As such, it is not clear why this “control group” was part of the study other than possibly to convince the reader that there was a fair comparison to a “control group,” which would artificially elevate the significance of the results from the active intervention group.

The treatment group had a single surgery or a combination of procedures based on the presurgical evaluation. The subjects had follow-up evaluations at 1 and 5 years, but there is no mention of who is performing these evaluations. Ideally, these evaluations should have been performed by independent neurologists. During the 1-year follow-up, the “control” subjects who received saline injections were given the option to proceed with surgery.

Results.—Among the 100 subjects in the treatment group, 91 had surgery, 89 presented for 1-year follow-up, and 79 presented for 5-year follow-up.

Among the 79 patients who presented at the 5-year follow-up, 10 received additional procedures. These 10 subjects were not included in the final analysis. It is interesting to note that these 10 patients had “significant improvement” of their migraines but still opted to proceed with additional procedures. One could assume that these patients had an outcome that would negatively impact the final results, and not surprisingly, these 10 subjects were not included in the final analysis. As such, of the original 91 treatment subjects who had anywhere from 1-4 procedures to produce mixed, unrefined data, 22 subjects did not present for follow-up, and 10 subjects wished to proceed with additional procedures due to inadequate results. Of the 22 subjects who did not present for follow-up, the reasons for not presenting may have included adequate treatment effect after the procedure, surgical failure to improve the subject’s headache, or untreatable complications from the procedure. Regardless, the study authors made a conscious decision to only include 69 of the treatment subjects, most of whom had favorable data in terms of 50% improvement of frequency, duration, or intensity, which again are not very good measures of surgical outcome as detailed above.

Among the 69 treatment subjects included in the final analysis, 6 (8.7%) had a single site procedure, 15 (21.7%) had surgery at 2 sites, 30 (43.5%) had surgery at 3 sites, and 18 (26.1%) had surgery at 4 sites.

Among the 69 treatment subjects included in the final analysis, 64 (93%) subjects had frontal trigger sites, 57 (83%) subjects had temporal trigger sites, 52 had intranasal triggers sites (75%), and 25 (36%) had occipital trigger sites.

It is assumed that the frontal trigger sites were bilateral procedures for cosmetic reasons, but there is no indication whether the temporal or occipital trigger site procedures were unilateral or bilateral. As one would imagine, performing surgery at multiple sites at once would make evaluating the efficacy of any single procedure difficult, especially since the vast minority (8.7%) of the subjects in the treatment group had a single site procedure.

At 5 years, 61 of the 69 subjects included in the analysis had a positive response. Twenty subjects (29%) had complete migraine elimination, and 41 (59%) had “significant” improvement of migraine with a 50% reduction of frequency, intensity, or duration. As with the placebo controlled trial, there was no mention of medication changes during the trial, and the measure of “significant improvement” is not a very good measure of a good surgical outcome as detailed above. There is again no mention of non-migraine headaches. Eight treatment subjects experienced no significant change (12%).

Adverse Events.—The subjects who proceeded with surgery experienced multiple complications that were present at 5-year follow-up. These complications included 20 subjects with occasional itching, 3 subjects had hair thinning at the surgical site, 2 subjects had hypersensitivity (frontal), 2 subjects had hypohypersensitivity (frontal), 2 subjects had numbness (frontal), and 3 subjects had mild occipital stiffness or weakness. One subject had facial nerve injury with complete recovery. The author specifically notes that no subjects had persistent *intense* itching at 5 years, which leaves the possibility that some degree of itching at the surgical site may have been present.

Author’s Conclusions.—The authors report that among the 69 subjects in the final analysis, 61 had improvement of their headaches at the 5-year follow-up evaluation. The author then comments that a placebo effect is highly unlikely in these subjects that have been followed over 5 years. It is then noted that in other studies, a positive response rate (reduction by 50%) of over 90% and a migraine elimination rate of over 70% is noted throughout the literature. The author then remarks that better detection and deactivation of trigger sites, as well as improving surgical techniques, may improve these success rates. The author specifically notes that resection of the temporal artery can be considered in cases involving the auriculotemporal branch of the trigeminal nerve. Regarding the lesser occipital nerve, the author advocates neurectomy and “burying the tied end of the nerve in the adjacent muscle” followed by triamcinolone injection to avoid neuroma formation. These additional surgical techniques are based on little evidence.

Commentary is then made about rebound headache, and subjects taking opiates, which is the only time the author comments on medications that are taken during the study. It is not surprising that the only medications noted by the author are those that may negatively impact study results (medication overuse headache), as there is no mention of preventative and abortive medications that can positively impact statistical analysis. The author once again lumps together these 4 procedures, and uses this collective weak data to reinforce these self-promoting curative surgical interventions.

COST ANALYSIS

The improvement of a patient's pain with nerve blocks or BTX could be used to persuade a patient to proceed with an expensive surgical treatment with unclear benefit and potentially irreversible complications including worsening of pain. Although the surgical literature cites a mean cost of \$8,378,³⁰ in my clinical practice, patients whose insurance company refused to cover the procedure have reported an upfront out-of-pocket estimated cost from the surgeon of \$15,000 for deactivation of a single trigger site. In clinical practice, if patients continue to experience pain in the area where the initial surgery was performed, revision surgeries are at times performed in the same area, or deactivation of other trigger sites are performed at additional cost.

This begs the question of how many surgeries is a desperate patient willing to endure and pay for in order to decompress nerves that may not be compressed. There are clearly clinical and financial ramifications that are not being considered in some surgical practices.

DISCUSSION

The 4 procedures collectively referred to as migraine headache trigger site deactivation surgery have been received with skepticism by headache specialists and neurologists since their inception. This skepticism may be due to the unclear mechanism of action of these surgeries in the context of the current pathophysiological models of migraine, as well as the potential irreversible complications of surgery.

One of the long-standing paradigms of surgery has been to select surgical cases based on a thorough risk to benefit ratio after failure of optimal medical management. Unfortunately, some patients proceeding with migraine headache trigger site deactivation surgery may not have had adequate trials of oral preventative medications, BTX, or nerve blocks. In addition, many of the subjects in these studies have episodic migraine, and may not have had adequate abortive medication trials.

When evaluating these surgical procedures, I tried to proceed with cautious optimism rather than blind skepticism. During my evaluation, I immediately thought of microvascular decompression surgery, which is a nondestructive procedure performed for the treatment of refractory trigeminal neuralgia. Peter Janetta, MD, is the neurosurgeon who pioneered this technique, and I had the opportunity to speak with Dr. Janetta regarding his experiences over the years while developing this procedure. The idea of microvascular decompression first came to Dr. Janetta while he was performing anatomical dissections for medical student education purposes. He noticed that vascular structures were compressing the trigeminal nerve, and he experimentally began decompressing this nerve in patients with refractory trigeminal neuralgia. Despite good outcomes, he initially encountered significant resistance from the neurology community regarding this procedure, but he let the data speak for itself. His opponents argued that he was in fact "damaging the nerve during the procedure" or that "compressing blood vessels do not exist." As the years passed, the evidence continued to grow regarding the efficacy of this procedure, and advancements in imaging technology allowed surgeons to make preoperative visualization of a clear surgical target. Dr. Janetta notes that it took about 20 years for this technique to be accepted as an effective treatment for trigeminal neuralgia. During our conversation, Dr. Janetta noted that the retirement of some of his opponents and the openmindedness of younger physicians played a role in the eventual acceptance of this treatment for trigeminal neuralgia.

Likewise, the 4 procedures that have been referred to collectively as migraine headache trigger site deactivation surgery may be effective interventions for

different types of head and face pain, but the decision to generalize these procedures as a treatment for a complex disorder such as migraine may have been presumptive.

In the case of the intranasal trigger zone, the associated procedure may be useful for the treatment of contact point headache.^{21,22} It is important to note that in a systematic literature review, it was found that most patients with contact points do not have headache or facial pain. In this review, surgical treatment of contact points was found to be inconsistently effective for the treatment of contact point headache.³¹ Although it is speculated that relief of the contact point against the nasal wall may lead to direct improvement of the pain, septoplasty and turbinectomy may also reduce upper airway resistance. This reduction in upper airway resistance may lead to improvement of sleep quality, and poor sleep is a well-known migraine trigger.⁴

In the case of the frontal trigger zone, the associated procedure may be useful for the treatment of supraorbital neuralgia. It has been established in the literature that some cases of supraorbital neuralgia may be due to nerve entrapment, which can be visualized with ultrasound imaging.²⁴ Subsequent decompression of the nerve has yielded some positive results.³² By the same logic, future studies may demonstrate that the occipital trigger zone procedure could potentially be useful for the treatment of occipital neuralgia.

In the case of the temporal trigger zone, the procedure should be modified to decompress a potentially entrapped nerve rather than performing nerve avulsions, as nerve destructive techniques are more likely to have complications.^{8,9}

It is possible that some of the positive results in the surgical literature may have actually been treating one of these other headache disorders in patients who also have migraines. Some of the mixed results may have treated the additional headache disorder, but the surgery exacerbated the subject's migraines. For example, an occipital procedure may alleviate occipital neuralgia, but the trauma of the surgery may worsen the patient's migraines.

It is clear that more rigorous studies need to be conducted in order to evaluate the potential efficacy

of each procedure. Future studies should look at each procedure individually rather than lumping the data together in order to report efficacy for any type of migraine. As such, subjects should not be receiving multiple procedures simultaneously. Presurgical evaluations should include objective testing to look for clear surgical targets, which may be suggestive of a headache disorder that exists in the presence or absence of migraine. For example, imaging studies could be performed to look for evidence of contact points for intranasal headaches or nerve compression in the cases of occipital neuralgia, supraorbital neuralgia, and other peripheral nerve disorders that can cause neuralgiform pain. Such screening tests may serve as better predictors of a positive outcome than BTX injections or nerve blocks. Sleep studies could also be considered before and after the intranasal procedure to determine the effects of this procedure on sleep.

Once appropriate subjects are selected, there needs to be matched surgical treatment groups and sham surgery groups with blinded independent neurologists conducting postsurgical evaluations. During the trial, subjects should be allowed to use their baseline abortive medications, but there should be no changes to preventative or abortive medications. In terms of endpoints, frequency of headache days per 28 days relative to baseline was the primary endpoint in the PREEMPT 2 trial for the evaluation of BTX as a preventative treatment for chronic migraine.¹⁷ This would serve as a more consistent endpoint than the endpoints used in some of the migraine surgical literature. Migraine frequency may exclude non-migraine headache days. Duration and intensity are endpoints that can be affected by the use of an effective abortive agent. The migraine index is an unvalidated measure which could serve to skew insignificant data into significance.

CONCLUSION

Migraine headache trigger site deactivation surgeries are a set of procedures that may potentially be useful in a subset of migraine patients with or without other coexisting headache disorders, but the supporting data at this time are not convincing. In addition to unclear efficacy, these expensive procedures also have

complications, which may have been under reported in the literature. In the near future, a case series of patients who experienced serious adverse events of prolonged or indefinite duration after migraine trigger site deactivation surgeries will be published.

All patients who wish to proceed with surgery should be informed of the risks and actual weak data supporting these procedures to date. The data available are not of good quality due to unclear patient selection, lack of sham group in some studies, and the omission of information regarding preventative/abortive medications utilized. Future trials should address these issues, and should avoid using ambiguous and unclear primary outcomes such as number of migraines, pain intensity, duration, and migraine index which are not validated endpoints in migraine studies.

Future studies may demonstrate that these procedures are useful in patients with imaging studies that demonstrate clear surgical targets that involve nerve compression or intranasal contact points. Future studies should target patients with contact point headache, supraorbital neuralgia, and occipital neuralgia, which are disorders that are more likely to have clear surgical targets. Treatment of these headache disorders may improve migraines in patients who have multiple headache disorders. As such, a more appropriate name for migraine headache trigger site deactivation surgery may be peripheral decompression surgery for the treatment of cranial neuralgias and contact point headache.

Patients who wish to proceed with migraine headache trigger site deactivation surgery outside of a clinical trial should at the very least have chronic daily headache, failed multiple preventative medications in the absence of medication overuse headache, failed trials of serial BTX injections, failed trials of serial nerve blocks, and have had an evaluation by a headache specialist. Although many practitioners may claim to be a headache specialist (plastic surgeons, chiropractors, etc), a headache specialist by definition is a physician who is board certified in headache medicine or has completed a headache medicine fellowship training program. Even if patients fulfill these minimum criteria, these patients should be informed that migraine headache trigger

site deactivation surgeries can have significant complications including worsening pain, and these procedures should be considered experimental at best based on available data.

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