Migraine trigger site deactivation surgery (MTSDS) is a term that encompasses four procedures that are performed for the preventative treatment of migraines. The theory behind these procedures is the peripheral mechanism theory of migraine. According to this theory, peripheral nerve compression serves as a trigger site for migraines. These procedures were devised by plastic surgeon Bahman Guyuron, MD after he claimed the headaches of patients who underwent forehead rejuvenation surgery for cosmetic purposes "went away" after surgery. It was suggested that these procedures permanently eliminate the migraine triggering muscle function that is only temporarily relieved by onabotulinum toxin type A (BTX). As the name implies, these procedures are performed based on migraine onset location.¹

For migraineurs with intranasal onset headaches, septoplasty and turbinectomy are performed. For migraineurs with frontal onset headaches, the corrugator supercilii, depressor supercilii, and procerus muscles are resected. For migraineurs with temporal onset headaches, a segment of the zygomaticotemporal branch of the trigeminal nerve is resected. For migraineurs with occipital onset headaches, a portion of the semispinalis capitis is resected, and the greater occipital nerve is then shielded using a subcutaneous flap to isolate it from surrounding muscles.²³

It is not clear why a nerve destructive procedure is performed for participants with migraines that originate in the temporal region, while nerve decompression is performed for the other procedures. It has been established in the literature that peripheral nerve damaging procedures have an increased risk of adverse events including numbness, paresthesias, dysesthesias, and even worsening of preoperative pain.⁴⁵ These side effects are often downplayed in the surgical literature, but a case series will be published in the near future detailing the potential side effects of MTSDS. This will include patients who have proceeded with surgery against my recommendation. In addition to side effects, MTDS can be quite expensive with an out of pocket cost as high as $15,000 per procedure. If the first MTSDS is unsuccessful, surgeons will often offer to perform revision surgeries in the same site and/or procedures in other sites at additional cost.

The comparison between the effects of MTSDS and BTX on migraine may oversimplify the complex biological activity of BTX, which likely works via multiple mechanisms rather than solely through pericranial and pericervical muscle relaxation. BTX can reduce the relay of afferent muscle stretch information to the central nerve system, which can lead to reductions in pain. BTX may also influence nerve terminals that contain substance P, calcitonin gene-related peptide, somatostatin, enkephalins, norepi-
nephrine, adenosine triphosphate, neuropeptide Y, and nitric oxide, which play varying roles in the pathophysiology of migraine.\textsuperscript{6-11}

Many of the participants in plastic surgery literature had episodic migraine (<15 headache days per month). As a screening tool in clinical practice and in plastic surgery studies, participants received 25 units of BTX, which is far less than the 155-200 units of BTX that was found effective for the treatment of chronic migraine in the pivotal PREEMT-2 trial, which demonstrated the efficacy of onabotulinum toxin type A (BTX) for the treatment of chronic migraine.\textsuperscript{12} The BTX studies that have been performed to date have failed to demonstrate the efficacy of BTX for episodic migraine. This would suggest that the positive responders actually responded to a low BTX dose or had a placebo response. In plastic surgery studies, positive responders would be surgical candidates eligible to participate. In clinical practice, it is not clear why some surgeons would proceed directly to a surgery with unproven efficacy and potential adverse events including worsening pain, rather than proceeding with higher doses of BTX, which is a treatment with better supporting data and transient, mild side effects.

Peripheral nerve blocks are also at times used for surgical screening. As the name implies, peripheral nerve blocks target the peripheral nervous system, but these procedures likely also influence central pain modulating structures. To illustrate this principle, a study demonstrated that migraine pain and brush allodynia in the trigeminal nerve distribution improved after occipital nerve blocks were performed.\textsuperscript{13} As such, the use of non-specific modalities such as BTX injections and nerve blocks would likely create false positives when used as a migraine surgery screening tool. This practice would be like a spine surgeon proceeding with a laminectomy after a patient’s pain improved with the use of a lidocaine patch. Although a laminectomy may effectively treat a percentage of these patients, it is an invasive surgery that should only be performed after specific diagnostic studies have been performed that establish a clear surgical target.\textsuperscript{14} It is questionable whether a surgeon performing MTSDS would offer or recommend standard doses of BTX or serial nerve blocks, as clinical improvement would likely deter patients from proceeding with surgery.

The studies that have been published in the plastic surgery literature boast impressive results for these procedures, and some surgeons have even used the term “cure” in reference to the results of surgery. Unfortunately the studies that have been conducted to date contain many methodological flaws, which invalidate many of the conclusions drawn by the authors.

These studies utilize unclear patient selection and unmatched groups. The initial evaluations of the participants were performed by neurologists in most studies, but it unclear who is performing follow-up evaluations. Ideally, an independent, blinded neurologist should be performing these evaluations.

Some studies inappropriately use the term “control group” even though no sham surgery was performed. In the study that contained an actual sham surgery control group, there was a 2:1 ratio of actual procedure to sham procedure.\textsuperscript{3} Such a ratio can, at times, drive a placebo effect if twice as many participants are receiving the actual intervention.\textsuperscript{15} The group that received the frontal procedure could not have actually been blinded, as the participants could likely appreciate the presence or absence of the cosmetic effects of the actual procedure versus the sham procedure.

During follow-up evaluations, invalid endpoints were utilized. Treatment success was defined as a 50 percent reduction in migraine frequency, intensity, duration, or the migraine headache index. Migraine frequency is a term that is very imprecise. The term migraine frequency may not properly account for migraines that last multiple days, headaches that lack migrainous features, and post surgical pain. Headache days per month is a more precise measure of frequency, and was the measure of headache frequency utilized in the PREEMT-2 trial.\textsuperscript{12}

Intensity and duration are variables that can be influenced by the participant using an effective abortive medication or even the patient sleeping to terminate an individual headache. For example, if a participant used a new triptan after surgery with effective termination of a headache in one hour, this would be considered a surgical success as there was a greater than 50 percent reduction in migraine duration. If there was unsuccessful termination of the headache, but the use of this triptan caused a 50 percent reduction in the intensity of the headache, this would also be considered a surgical success. Neither preventative nor abortive medications utilized by the participants during the study are disclosed in two of the larger plastic surgery studies.\textsuperscript{2,3}

The migraine headache index is calculated as follows: (frequency X intensity X duration). As one can imagine, if frequency, intensity, and duration are invalid endpoints, the migraine headache index is an equation that can be used to skew insignificant data into artificial significance. For example, if a participant were to experience a 17 percent reduction of migraine frequency, intensity, and duration, that participant’s migraine headache index would have been reduced by greater than 50 percent.

Some participants received multiple procedures simultaneously, so single procedure efficacy could be determined.
Patients who are considering MTSDS should have an evaluation by a headache specialist, and should be advised of the actual risks these procedures can have in the absence of any convincing evidence of efficacy.

In some studies, “significant improvement” was appreciated by some participants, but they still opted to proceed with additional surgery during follow-up periods. These patients were excluded from the final data analysis for unclear reasons. If one group of participants with an unfavorable surgical outcome was excluded, it would not be surprising if other subgroups with unfavorable outcomes may have also been excluded from the final analysis.

One possible explanation for some of the positive outcomes is that some of the participants were misdiagnosed with migraine, or they suffered from another undiagnosed headache disorder in addition to migraine, which responded to MTSDS. In clinical practice, it is common for patients to have both migraine and another headache disorder, such as occipital neuralgia. Effective treatment of the second co-existing headache disorder can at times lead to an improvement of the underlying migraine. Participants who experienced improvement after the intranasal trigger site procedure was performed may have had contact point headache. Alternatively, the participant may have had sinus disease or a sleep breathing disorder that responded to the intranasal trigger site procedure. Participants who experienced improvement after the frontal trigger site procedure may have had supraorbital neuralgia. Participants who experienced improvement after the occipital trigger site procedure may have had occipital neuralgia.

One of the long time paradigms in medicine is to proceed with elective surgery based on a favorable risk to benefit ratio, and once best medical management has failed. The majority of patients in two of the larger studies had episodic migraine, and some of these patients may not have failed best medical management prior to entering these trials. In clinical practice, MTSDS is likely being performed in patients who have not failed optimal medical management including trials of oral preventative medications, BTX injections, and/or nerve blocks. The American Headache Society does not endorse the treatment of migraine with MTSDS. Patients who are considering MTSDS should have an evaluation by a headache specialist, and should be advised of the actual risks these procedures can have in the absence of any convincing evidence of efficacy. By definition, a headache specialist is someone who has completed an accredited headache medicine fellowship or is board certified in headache medicine. MTSDS may be effective in a subset of patients who have another headache disorder in the presence or absence of underlying migraine, but the supporting data for MTSDS are not convincing at this time. These procedures should be considered experimental at best until further studies have demonstrated efficacy.

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