In-Depth Review of Symptoms, Triggers, and Treatment of Temporal Migraine Headaches (Site II)

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Background: This study was designed to report the details of the technique and assess the efficacy of surgical deactivation of temporal-triggered migraine headaches. It also examined the effect of surgical deactivation of temporal-triggered migraine headaches on migraine triggers and associated symptoms besides the pain.

Methods: The authors analyzed the charts of 246 patients receiving surgery for temporal-triggered migraine headaches by a single surgeon (B.G.) over a 10-year period, who were followed for at least 1 year. Median regression adjusted for age, sex, and follow-up time was used to determine postoperative reduction in temporal-specific migraine headache index, which is the product of frequency, severity, and duration. The association between individual symptom or trigger resolution and index value reduction was studied by logistic regression. Details of the surgical treatment are discussed.

Results: Eighty-five percent of patients reported a successful surgery (≥50 percent improvement of headache index) at least 12 months after surgery (mean follow-up, 3 years). Fifty-five percent reported complete elimination of temporal migraine headache. Symptoms resolving with successful site II surgery included nausea, photophobia, phonophobia, difficulty concentrating, vomiting, blurry vision, and eyelid ptosis ($p < 0.05$). Triggers resolving included letdown after stress, air travel, missed meals, bright lights, loud noises, fatigue, weather change, and certain smells ($p < 0.05$).

Conclusions: Surgical deactivation of temporal-triggered migraine headaches is effective regardless of age, sex, or follow-up time. Successful site II surgery is associated with changes in specific symptoms and triggers. This information can assist in trigger avoidance and contribute to constellations used for temporal-triggered migraine headaches trigger-site identification. (*Plast. Reconstr. Surg.* 133: 897, 2014.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, IV.

Migraine headaches burden 35 million Americans, including 17 percent of women and 6 percent of men.[1] In 2010, migraine headaches were associated with $3.2 billion in outpatient costs, $700 million in emergency room costs, and $375 million in inpatient hospitalizations in the United States.[1] Most migraine headache sufferers manage their symptoms with a combination of nonpharmacologic (e.g., avoidance of environmental triggers) and pharmacologic interventions (e.g., acute abortive, acute analgesic, and prophylactic medications). The total cost for these drugs is estimated to be $1.5 billion annually.[2]

The pathophysiology of migraine headaches remains controversial. It is the opinion of the senior author (B.G.) that musculature, vessels, bony foramen, and possibly fascial bands around trigeminal nerve branches irritate trigeminal nerve branches, leading to inflammation and pain associated with migraine headaches. Anatomical studies support this notion.[3–10] On the basis of this theory, the senior author developed surgical techniques to deactivate four common migraine headache

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trigger sites (site I surgery for frontal-triggered migraine headaches, site II surgery for temporal-triggered migraine headaches, site III surgery for septonasal-triggered migraine headaches, and site IV surgery for occipital-triggered migraine headaches). Temporal-triggered migraine headaches are the most common.

Temporal-triggered migraine headaches result from temporal muscle contraction around the zygomaticotemporal branch of the trigeminal nerve, pulsation of the concomitant vessel, tight deep temporal fascia opening through which the nerve exits, or various combinations of these, irritating these nerve branches.[11] The zygomatic branch of the trigeminal nerve is entirely sensory, and it originates by diverging from the maxillary division of the trigeminal nerve in the pterygopalatine fossa. The zygomatic nerve courses on the lateral orbital wall in the inferior orbital fissure and terminates by bifurcating into the zygamaticofacial branch of the trigeminal nerve and the zygomaticotemporal branch of the trigeminal nerve.

The zygomaticotemporal branch of the trigeminal nerve traverses a bony canal of the zygomatic bone and terminates in the temporal fossa (Fig. 1). Distal to the foramen, it travels either between the bone and temporal muscle (about 50 percent of cases), within the muscle via a brief course (about 25 percent of cases), or within the muscle via a tortuous course (about 25 percent of cases).[3] Finally, it pierces the temporal fascia to innervate skin of the temporal region. The point of temporal fascia piercing was described in a study of 19 female cadavers and one male cadaver

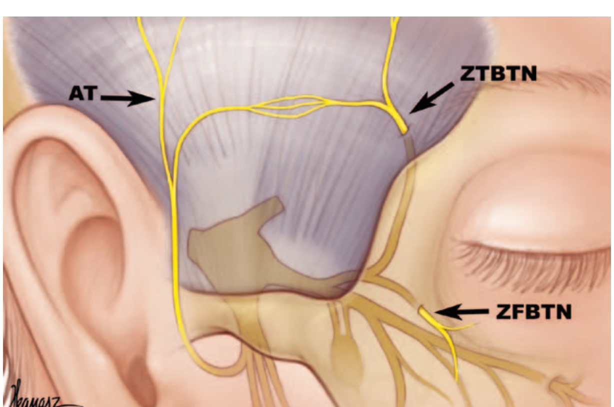

Fig. 1. Zygomaticotemporal branch of the trigeminal nerve. *AT*, auriculotemporal; *ZTBTN*, zygomaticotemporal branch of the trigeminal nerve; *ZFBTN*, zygomaticofacial branch of the trigeminal nerve. Reprinted with permission from Totonchi A, Pashmini N, Guyuron B. The zygomaticotemporal branch of the trigeminal nerve: An anatomical study. *Plast Reconstr Surg*. 2005;115:273–277.

as 17 mm lateral and 6.5 mm cephalad of the lateral canthus.[6] The zygomaticotemporal branch of the trigeminal nerve rarely arborizes within the zygomatic bone (exiting via multiple foramina), with arborization more frequently within the temporalis muscle or fossa.[3] Of the 20 specimens in the above-mentioned cadaveric study, 12 had zygomaticotemporal branch of the trigeminal nerve accessory branches cephalad, posterolateral, or adjacent to the main branch.[6]

Constellations of symptoms and triggers have been shown to be as effective as serial botulinum toxin A injection for diagnosis of correct migraine trigger site, although the specific symptoms and triggers have not been individually evaluated for site-specific associations.[12]

The research team has performed retrospective,[13] prospective,[14,15] and placebo-controlled[16] studies that support the utility of surgery in deactivating migraine trigger sites. Other research groups have replicated these results.[17–19] This retrospective study examines the effect of site II surgery on temporal-triggered migraine headaches' frequency, duration, and severity and reviews the technical surgical details. This is the first study to associate specific triggers and symptoms with temporal-triggered migraine headaches and is the largest study to analyze specifically site II surgery outcomes.

PATIENTS AND METHODS

Patient Selection

Institutional review board approval was obtained for this retrospective review of prospectively recorded information. A detailed history was obtained to diagnose migraine headaches. The temporal trigger site was identified by either systematic injection of botulinum toxin type A or the constellation of symptoms. The study included patients who proceeded with surgery for temporal-triggered migraine headaches by a single surgeon (B.G.) between August 1, 2000, and April 30, 2011, had been followed for 12 months or longer, had completed a preoperative migraine headache questionnaire, and had completed a postoperative migraine headache questionnaire 12 months after surgery.

Preoperative Procedure

Patients completed a migraine headache questionnaire before surgery to assess migraine frequency (number per month), duration (in days), severity (scale of 1 to 10, with 10 being most severe), and anatomical location of pain (yes/no report of migraine originating from right or left frontal, temporal, septonasal, or occipital regions). A preoperative migraine index value was calculated by multiplying the frequency, duration, and severity. The preoperative temporal migraine index value was assumed to equal the overall migraine index in the presence of diagnosed temporal-triggered migraine headaches. In addition, the questionnaire asked patients to select from 16 symptoms and 13 triggers they may have observed in the month before the final preoperative visit.

Surgical Technique

The surgical technique was as follows.[11] After appropriate preparation of the head and face, two 1.5-cm lines were drawn approximately 7 and 10 cm lateral from the midline of the scalp in the hair-bearing regions of the left and right temples. The forehead, temple, and malar regions were then injected with 1% lidocaine with 1:100,000 epinephrine; the scalp was injected with 0.5% lidocaine with 1:200,000 epinephrine. After the incisions were made with a no. 15 scalpel, they were deepened with spreading effects of baby Metzenbaum scissors to the deep temporal fascia. The dissection was continued using a periosteal elevator. The Endoscopic Access Devices (Applied Medical Technology, Cleveland, Ohio) were inserted. The periosteal elevator was used to raise the periosteum posteriorly and cephalically. A subperiosteal dissection was then carried out under endoscopic visualization immediately superficial to the deep temporal fascia, and the zygomaticotemporal branch of the trigeminal nerve was exposed. To reach this nerve safely, it is crucial to identify the deep temporal fascia beneath the scalp incision and to continue the dissection in this plane. All of the fat should be lifted with the skin and superficial temporal fascia. Transcutaneous tattooing of the nerve site by the measurement from the lateral canthus (17 mm lateral and 6.5 mm cephalad to the lateral canthus) was used to forewarn the surgeon about the location of the nerve during the early stages of the senior author's experience. Dissection immediately superficial to the deep temporal fascia was conducted medially until the nerve was exposed. Grasping forceps were used to avulse the nerve, and any accompanying vessels were coagulated. As much length (often about 3 cm) of the nerve as possible was avulsed to prevent recoaptation; the proximal nerve end was allowed to retract into temporalis muscle to reduce the risk of neuroma formation. The periosteum and arcus marginalis were released in the lateral orbital and supraorbital regions for transposing and fixing the soft tissues in patients older than 30 years merely for the rejuvenation side benefits of the surgery.[14] In patients who were candidates for a lateral suspension, the endoscopic access devices were removed, and a single hook was placed on either side of the caudal portion of the incision. A 3-0 polydioxaone suture was used to fix the superficial and intermediate temporal fascia to the deep temporal fascia laterally. In younger patients, no lateral suspension was carried out. A no. 10 TLS drain was placed, and the skin incisions were repaired with 5-0 poliglecaprone 25 (Monocryl; Ethicon, Somerville, N.J.) and 5-0 plain catgut interrupted stitches. Figure 2 depicts the procedure's critical steps.

The drain was removed on postoperative day 2, and the patient was allowed to return to light activities the next day, regular activities within 7 days, and heavy activities within 3 weeks. The recent modification of this technique eliminated the use of the drain.

Postoperative Procedure

Patients completed a migraine headache questionnaire every 3 months. In addition, at 12 or more months after surgery, a postoperative migraine index value was calculated. The temporal migraine index was assumed to equal the overall migraine index if temporal-triggered migraine headaches persisted postoperatively. Elimination of migraines was defined as zero reported migraines in the temporal region. A successful site II surgery was defined as temporal migraine index reduction of at least 50 percent during the 12-month follow-up. Patients also reported symptoms and triggers they experienced in the month before each visit.

Statistical Analysis

Exploratory and descriptive statistics are used in summarizing demographic and clinically relevant (e.g., temporal migraine index reduction) variables. Reductions in temporal-triggered migraine headache frequency, duration, and severity were tested using basic tests (e.g., chi-square test) with a significance level of 0.05. For skewed response variables, median regressions adjusted for age, sex, and follow-up time are used to determine postoperative reduction in temporal-specific migraine headache index. The association between individual symptoms or trigger resolutions and temporal-specific migraine headache index reduction are studied by logistic

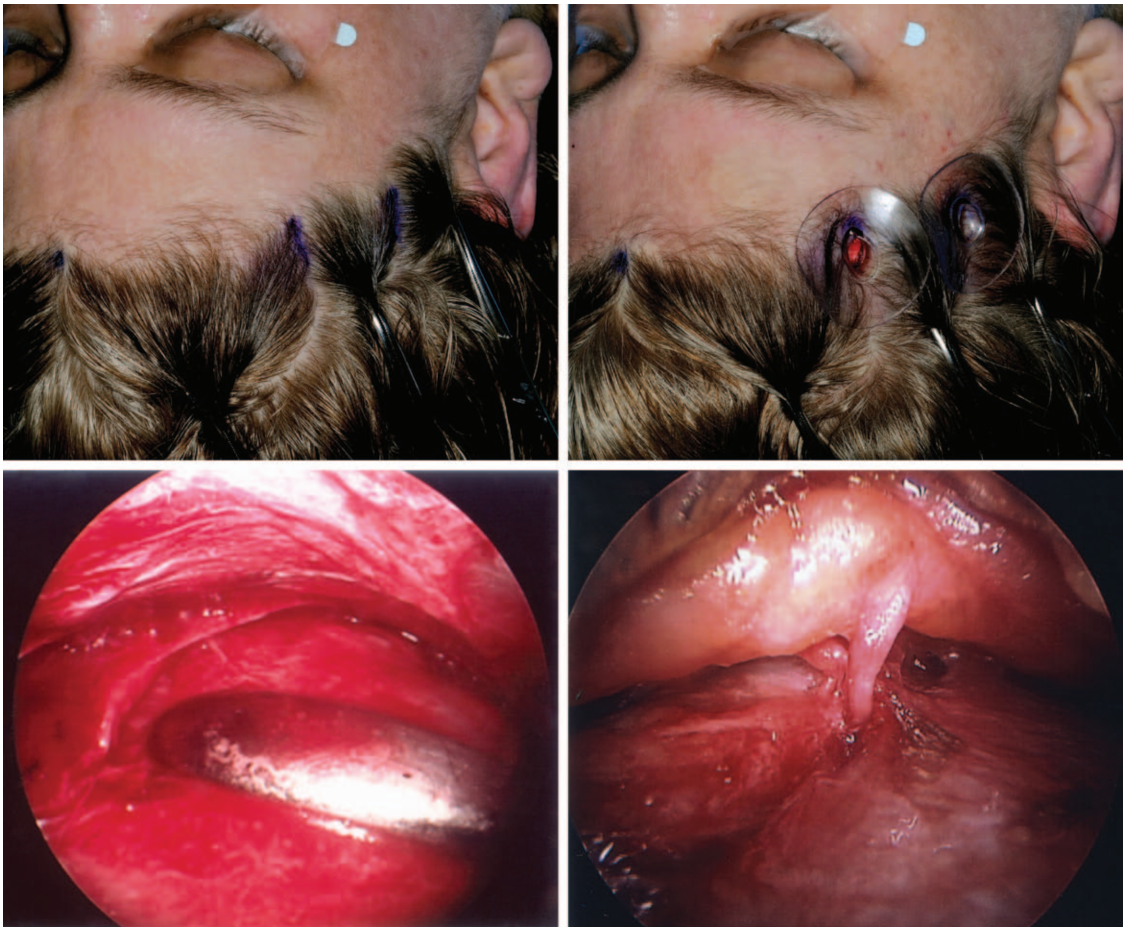

Fig. 2. Critical steps of site II surgery. (*Above*, *left*) Markings 7 cm and 10 cm from midline. (*Above*, *right*) Insertion of endoscopic access devices. (*Below*, *left*) Dissection in the supraperiosteal plane. (*Below*, *right*) Avulsion of the zygomaticotemporal branch of the trigeminal nerve.

regressions. Odds ratio estimates and 95 percent confidence intervals are reported. All analyses were performed using Stata 11.0 (StataCorp, College Station, Texas).[20]

RESULTS

Overall Surgery Outcome

Two hundred forty-six patients (223 female and 23 male) with a median age of 46 years were included for analysis in this study after exclusion of 124 patients who were not followed for at least 1 year. Follow-up ranged from 12 to 120 months, with a mean follow-up of 3.21 years (SD, 1.79). Seventy-five percent of patients received botulinum toxin injection as part of their diagnostic workup, with the rest diagnosed by constellation of symptoms alone.

Eighty-five percent of patients experienced 50 percent or more temporal migraine index reduction, including 55 percent who experienced temporal migraine elimination. Migraine frequency (mean, 71 percent reduction), duration (mean, 72 percent reduction), and severity (mean, 63 percent reduction) were each significantly decreased postoperatively ($p < 0.0001$). Age, sex, use of botulinum toxin for diagnosis, and follow-up time had no effect on surgical efficacy ($p > 0.05$). Among those patients with complete migraine elimination at site II, and among all patients, the overall migraine headache index decreased significantly from before to after surgery ($p < 0.05$).

Among the 21 patients who had site II surgery without concomitant surgery, the site II migraine headache index decreased significantly from before to after surgery ($p < 0.05$). However, compared with the patients who had multisite surgery, the 21 patients who had only site II surgery had significantly less improvement ($p < 0.05$). Botulinum toxin was used in 18 of these patients for diagnosis.

Table 1. Symptom Association with Site II Migraine Headache Index Reduction*

Symptom	No. of Patients	OR	*p*	95% CI
Nausea	***167***	***22.01***	***0.001***	***(3.62–133.75)***
Bothered by light and noise	***183***	***3.03***	***0.016***	***(1.23–7.48)***
Eyelid puffy	63	3.52	0.139	(0.67–18.60)
Feeling lightheaded	83	1.6	0.163	(0.83–3.11)
Difficulty concentrating	***164***	***2.43***	***0.017***	***(1.17–5.06)***
Running nose	68	2.01	0.213	(0.67–6.02)
Vomiting	***114***	***3.79***	***0.010***	***(1.37–10.46)***
Blurred/double vision	***87***	***4.07***	***0.010***	***(1.41–11.77)***
Eyelid ptosis	***46***	***3.94***	***0.039***	***(1.07–14.46)***
Numbness/tingling	55	1.58	0.135	(0.87–2.89)
Speech difficulty	47	2.71	0.068	(0.93–7.94)
Diarrhea	47	1.47	0.617	(0.33–6.56)
Visual aura	74	1.19	0.743	(0.42–3.33)
Vision loss	22	1.08	0.939	(0.16–7.54)
Limb weakness	28	0.979	0.983	(0.14–6.88)
Loss of conscious	14	1.52	0.754	(0.11–20.96)

*Bold and italic values are significant ($p = 0.05$).

Symptoms and Triggers

Symptoms with resolution significantly associated with decrease in temporal-specific migraine headache index value included nausea, being bothered by light and noise, difficulty concentrating, vomiting, blurry vision, and eyelid ptosis ($p < 0.05$). Odds ratios and confidence intervals are listed in Table 1. Odds ratio describes the likelihood of symptom resolution in patients who benefited compared with those who did not benefit from surgery.

Triggers with resolution significantly associated with a decrease in temporal-specific migraine headache index value included letdown after stress, air travel, bright lights, loud noises, fatigue, weather change, and smells ($p < 0.05$). Odds ratios and confidence intervals are listed in Table 2.

DISCUSSION

These results provide strong support for the efficacy of surgery to reduce the frequency, duration, and severity of temporal-triggered migraine headaches. Eighty-five percent of patients experienced significant benefit from surgery. Furthermore, a mean 3-year follow-up indicates the enduring nature of these improvements. In the context of the senior author's 2009 randomized controlled study demonstrating the efficacy of actual migraine surgery over sham surgery, these results support the avulsion of the zygomaticotemporal branch of the trigeminal nerve, as opposed to the placebo effect, to be the primary reason for reduction or elimination of symptoms.

Despite high rates of success, the inability to eliminate temporal-triggered migraine headaches in all patients suggests room for improving our methods and the need to pursue research regarding temporal-triggered migraine headache pathogenesis and surgical techniques. Anatomic studies have demonstrated the variable branching pattern of the zygomaticotemporal branch of the trigeminal nerve. Improved ability to visualize and subsequently deactivate all of its branches could lead to a higher incidence of migraine elimination. The auriculotemporal nerve may have been

Table 2. Trigger Association with Site II Migraine Headache Index Reduction*

Trigger	No. of Patients	OR	*p*	95% CI
Stress (worry, anger)	128	1.71	0.147	(0.83–3.52)
Letdown after stress	***75***	***3.96***	***0.040***	***(1.06–14.77)***
Air travel	***52***	***344.67***	***0.012***	***(3.62-32788.5)***
Missed meals	***94***	***6.02***	***0.013***	***(1.45–24.92)***
Certain foods	98	2.04	*0.083*	(0.91–4.55)
Bright sunshine	***125***	***6.65***	***0.004***	***(1.86–23.82)***
Loud noise	***106***	***6.14***	***0.006***	***(1.66–22.69)***
Fatigue	***100***	***3.63***	***0.008***	***(1.40–9.45)***
Sexual activity	11	0.194	0.694	(0.00–694.94)
Weather change	***123***	***13.65***	***0.006***	***(2.13–87.49)***
Heavy lifting	29	2.29	0.301	(0.48–10.99)
Certain smells or perfume	***113***	***487.57***	***<0.001***	***(15.41-15424.64)***
Coughing, straining, bending over	60	1.35	0.430	(0.64–2.86)

*Bold and italic values are significant ($p = 0.05$).

overlooked as a cause of migraine in some patients. Recent anatomic studies reveal an intimate relationship between the auriculotemporal nerve and superficial temporal artery in about one-third of cases, including occasional helical intertwining.[21]

Elucidating symptoms and triggers associated with temporal-triggered migraine headaches is valuable for trigger site identification. Patients seeking surgery for migraine headaches typically present with undifferentiated trigger locations. In order to avoid the time- and resource-consuming process of serial botulinum toxin A injection, the surgeon must take into account location of pain and associated symptoms and triggers in order to select the appropriate surgical site. The temporal-triggered migraine headache symptoms and triggers identified here are, at most, specific to this type of migraine headache and, at least, related to migraine headaches in general. Study of symptoms and triggers at other anatomic sites will elucidate values for sensitivity and specificity and further improve preoperative diagnosis.

Triggers can occasionally be identified through a preoperative journal, and surgery with its inherent risks can be avoided. Understanding the triggers related to temporal-triggered migraine headaches can hone trigger avoidance practices, and patients with these migraine headaches who are not surgical candidates can be counseled on which triggers to avoid.

Loss to follow-up was a limitation. Many patients traveled from out of state and out of country for treatment, which makes long-term contact difficult. In addition, deducing preoperative and postoperative temporal migraine index values from the overall migraine index value was a limitation. We assumed that a patient who reported migraines in two or more sites either preoperatively or postoperatively had equal migraine index values at each site. Ideally, each patient would have reported frequency, duration, and severity for each migraine trigger site, including the temporal site, and we are currently more focused on obtaining this type of detailed information. We are also conducting a prospective randomized study to compare the outcome of nerve avulsion to that of nerve decompression. Finally, there is a possibility that the periosteal dissection associated with the brow lift procedure received by many female patients older than 30 years of age provided a confounding benefit due to released supraorbital and supratrochlear nerves.

Although the research team has demonstrated independence of each anatomic site,[12] it is possible that symptom and trigger changes in patients with concomitant surgery were influenced by surgery at distant sites. Twenty-one patients (8.5 percent) received site II surgery only, 215 (87.3 percent) received concomitant site I surgery, 159 (64.6 percent) received site III surgery, 121 (49.2 percent) received site IV surgery, and two (0.8 percent) had site V (auricotemporal nerve decompression) surgery. In addition, overall migraine headache index decreased significantly among the patients who experienced complete elimination of site II headaches. Although we have seen on an individual basis that site II surgery can unmask pain at other anatomic locations, this effect was not significant on a larger scale.

Although the 21 patients receiving only site II surgery showed significant improvement, the amount of improvement was less than that seen in the patients who received multisite surgery. This could be an aberrant finding related to small sample size. It could also be related to undiagnosed pain caused by the auriculotemporal nerve, which was not identified as a trigger site until more recently.

Adverse consequences of site II surgery have been documented previously in a study by the senior author. In that study of 19 patients undergoing site II surgery, one patient (5 percent) had numbness 1 year postoperatively, 10 patients (53 percent) had slight temporal hollowing, and one patient (5 percent) had temporary hair loss.[16]

CONCLUSIONS

This study is the largest to examine site II (temple) surgery and demonstrates the efficacy of this procedure for improving the frequency, duration, and severity of temporal-triggered migraine headaches, as well as numerous symptoms and triggers. It also outlines the technical details and the anatomical nuances. Future research will describe outcomes and associated symptoms and triggers for each of the other surgical sites.

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