Access this article online
Quick Response Code:

Website: www.neurologyindia.com
DOI: 10.4103/0028-3886.315999

Surgical Options for Migraine: An Overview

Ali Totonchi, Bahman Guyuron[1], Hossein Ansari[2]

Associated Professor of Plastic surhery Case Western Reserve University, Metro health Hospital, Cleveland, [1]Editor In Chief, Aesthetic Plastic Surgery Journal Professor Emeritus, Plastic Surgery Case School of Medicine Zeeba Clinic, Lyndhurst, OH, [2]Director of Headache and Facial Pain Clinic Kaizen Brain Center, Associate Professor of Neuroscience University of California 9500 Gilman Drive La Jolla, California, USA.

Address for correspondence:
Dr. Hossein Ansari, Associate Professor of Neuroscience University of California 9500 Gilman Drive La Jolla, CA, 92093-5004, Director of Headache and Facial Pain Clinic Kaizen Brain Center 4180 La Jolla Village Drive ,Suite 240 La Jolla , CA , 92037, USA
E-mail: headache@hansari.com

Abstract:

Objective: The goal of this manuscript was to provide a comprehensive review of the surgical treatment for migraine headaches with a focus on trigger points and their clinical presentations, and to emphasize the importance of appropriate patient selection.

Background: Migraine is a prevalent neurological disease with headache being a disabling component of it. Surgical treatment for migraine headache became available two decades ago, which is based on proper identification and the deactivation of the specific *trigger sites* in the head and neck area.

Design: This manuscript reviews the discovery and evolution of migraine surgery with changes in patients' selection throughout the years.

Conclusion: Patients with migraine headaches who do not respond or cannot tolerate the medical treatment might benefit from trigger site deactivation surgery. The success of the surgery is closely related to proper identification of trigger point (s) and close collaboration with a neurologist or a headache specialist. This collaboration would enhance patients' positive outcomes and help to rule out other causes of the headache.

Key Words:

Headache, migraine, migraine surgery, occipital nerve, peripheral, preventive, trigeminal nerve, trigger points

Key Massage:

Migraine surgery could be considered as a preventive treatment based on the role of peripheral mechanisms in the pathophysiology of migraine. Proper determination of trigger points which are branches of trigeminal or occipital nerves is the key to success.

Migraine is a complex neurological disorder known since ancient times based on available literature. It is the most prevalent neurological disorder worldwide. Despite advances in our understanding of the pathophysiology of the disease, there is an unmet need for better treatment of this condition. Migraine is still one of the leading causes of disability worldwide, particularly in younger ages where it has been reported to be the principal cause of disability.[1,2]

As a complex brain disorder, the central nervous system plays a critical role in the pathophysiology of migraine, and the "*brainstem migraine generator*" has been described years ago.[3,4] Later advancements in understanding the pathophysiology of migraine revealed the role of different parts of the central nervous system in migraine, including the cerebral cortex and hypothalamus has been identified.[5,6]

Migraine has been classically described to have four phases: the premonitory, aura, headache, and postdrome phase although all need not be present during each and every attack.[7] For most patients, the headache phase is the most important and bothersome phase during a migraine attack. Activation of the "trigeminovascular" pain pathways that innervate the dural vasculature is thought to be responsible for the headache phase of the migraine.[8]

The role of the "trigeminovascular" complex in the headache phase of migraine is well described. It is believed that peripheral and central sensitization of the "trigeminovascular" complex may contribute to migraine headaches.[9] Within the past decade, the important role of Calcitonin Gene-Related Peptide (CGRP) has been identified as being released in the trigeminovascular complex, leading to neurogenic inflammation and vasodilation. However, the activation site of CGRP remains open to discussion with a growing body of evidence supporting a peripheral site of action of CGRP as well.[10]

How to cite this article: Totonchi A, Guyuron B, Ansari H. Surgical Options for Migraine: An Overview. Neurol India 2021;69:S105-9.

Submitted: 28-Jan-2021 **Revised:** 01-Feb-2021
Accepted: 02-Mar-2021 **Published:** 14-May-2021

Background

Surgical management for migraine was attempted by Dr. Harvey Cushing - the father of modern neurosurgery during the early 1900s, but many of his results were never published because many of his procedures proved to be unsuccessful.[11]

The current trend in migraine surgery was started by the senior author (BG) in 1999 when two of his patients reported relief of their headache after forehead rejuvenation. In this surgery usually, glabellar muscles are removed around the supraorbital and supratrochlear nerves.[12] This incidental finding along with the discovery that *Botulinum toxin A* is beneficial for treating headaches in some individuals prompted the senior author to conduct a retrospective study. The common grounds between *botulinum toxin A* injection and forehead surgery were deactivation of the glabellar muscles. However, other attributes of botulinum toxin A may have a role in reducing or halting migraine headaches.[13]

In the beginning, the hypothesis was that sensory nerves are being compressed or irritated by the muscles around them.[14] However anatomical studies suggested that nerves can be compressed or irritated by other structures like vessels, fascia, and bone.[15-18]

The idea of trigger site deactivation using an injection of local anesthetics in migraine patients has been recorded in neurology literature as well and it is routinely used in practice by headache medicine providers.[19]

Since the initial observation, more than 60 scientific studies have been published by multiple centers to further validate the concept of migraine surgery, including a placebo-controlled (sham surgery) by the senior author of this review.[14,20-24] Further anatomical studies delineated the course of the nerves in the head and neck area, and surgical techniques have been refined.[15,16]

Evaluation

Overall, four major trigger sites and a few minor trigger sites have been described in the surgical treatment of migraine headache:

- Major trigger sites include the forehead, temporal, occipital, and nasal trigger points.
- Minor trigger sites consist of the auriculotemporal nerve, lesser occipital nerve, and peripheral branches of any of the above-mentioned nerves.

Initially, *botulinum toxin A* was used for patient selection but throughout the years we learned that constellations of symptoms and diagnostic nerve blocks for identification of trigger points could be as helpful.[25,26] Therefore, with a careful history and detailed headache diary plus a thorough head, neck, and nose exam, we are usually able to identify the correct trigger point/s. A computerized tomography (CT scan) of the nose and paranasal sinuses is useful in nasal trigger sites and the use of Doppler ultrasound could be helpful in some peripheral and smaller trigger sites.[27]

Trigger Site Identification and Treatment

Frontal trigger site:

Involved nerves: supraorbital and supratrochlear nerves

The constellation of symptoms: patients' headache starts from the frontal area, above the eyebrows which could be unilateral or bilateral. These patients usually have strong frowning muscles. Patients with the chronic frontal trigger might develop eyebrow or eyelid ptosis. Blocking of the affected nerve with a local anesthetic alleviates the patient for a short period and has diagnostic value.

Pathophysiology: the nerves could be irritated by either glabellar muscles (including the corrugator supercilii, depressor supercilii, and procerus) or vessels accompanying them. In some patients, nerves are also under significant pressure in the supraorbital notch by a fibrous band or bony tunnel [Figure 1]**.** However, the vessels have a prodigious role in this site.

Surgical procedure: The focus is to relieve the Supraorbital and Supratrochlear nerves from any pressure, this is done by an incision on the eyelid or endoscopically and skeletonizing the nerves throughout their pass from orbital rim to subcutaneous tissue, this usually involves removal of Corrugator, part of procerus and depressor supercilii muscles, removal of the accompanying vessels and release of the nerve in the supraorbital rim from any pressure caused by a notch or bony tunnel.[12] In the end, nerves are wrapped with a fat graft, or the area is injected with fat to minimize the scarring and possible recurrence of the nerve irritation. The supraorbital and supratrochlear vessels are removed as thoroughly as possible.

Temporal trigger site

Involved nerves: Zygomaticotemporal and auriculotemporal nerves

The constellation of symptoms: Headache starts on the temple, usually one side is more prominent, and headache often presents in the morning. Patients usually have a history of teeth clenching or grinding. Jaw pain is very common in this patient and often misdiagnosed as temporomandibular joint disorder (TMD).

Figure 1: Supraorbital nerve passing through supraorbital notch, a thick band putting pressure on the nerve which is retracted by end of scissors

It is very important to differentiate the pain originating from the Zygomaticotemporal branch of the trigeminal (ZTBTN) nerve and Auriculotemporal nerve (ATN). Patients with ZTBTN trigger point usually point toward the hallowing in the temporal area which is located around 17 mm posterior to the lateral orbital commissure is 6 mm cephalic to it. On the other hand, patients with auriculotemporal trigger points have their pain more posterior, along the temporal hairline.

Pathophysiology: ZTBTN can be compressed by temporalis muscle, deep temporal fascia, or vessels. ATN can be irritated by vessels traveling with it (superficial temporal artery) or fascia.

Surgical procedure: ZTBTN is treated endoscopically by avulsion of the nerve [Figure 2] as it emerges from the deep temporal fascia. ATN is more superficial and treated with a small incision identification and transection of a small segment of the superficial temporal artery or removal of the nerve [Figure 3].

Intranasal Trigger site (*Rhinogenic Migraine*)

Involved nerves: Rich nervous supply of nasal mucosa. These sensory nerves are branches of the maxillary nerve through sphenopalatine ganglion.

The constellation of symptoms: Headache starts from behind the eye and usually is unilateral at the onset. Patients usually wake up in the morning with a headache. Whether or barometric changes can trigger the headache by affecting the size of the turbinate or lining of the concha bullosa. Since nasal mucosa size responds to hormonal fluctuation, these patients usually experience prominent menstrual migraines. Treatment with *botulinum toxin A* is usually not effective in this group. On the other hand, these patients often get relief using intranasal decongestants or oral antihistamine and therefore commonly mistaken for sinus disorder and label as "*sinus headache*."[28] Also since they can have rhinorrhea, nasal congestion, and breathing difficulty and therefore can be mistaken for cluster headache or other trigeminal autonomic cephalalgias.

Pathophysiology: Irritation of rich nervous supply of nasal mucosa due to the anatomical contact point (septum or turbinate) or pressure from entrapped air pocket (concha bullosa) [Figure 4].

Surgical procedure: Depends on the anatomic pathology, septoplasty, elimination of contact points between the turbinate and the septum, reduction of the enlarged turbinate, and decompression of concha bullosa.

Occipital trigger site

Involved nerves: Greater Occipital Nerve (GON), Lesser Occipital Nerve (LON), and rarely Third Occipital Nerve (TON)

The constellation of symptoms: Pain starts from the occipital and neck area, throbbing and stabbing in nature. Stress has a high impact on this trigger point, also physical activity can make it worse. Patients usually complain of neck and shoulder muscle tightness particularly with sitting or sleeping in certain positions. They tend to change their pillow to help this tightness. In neck exams, there is significant tenderness on pressure or even tapping on the affected nerve. History of a neck injury, particularly whiplash-type injury may correlate with onset/worsening of headaches. This type of migraine is commonly mistaken

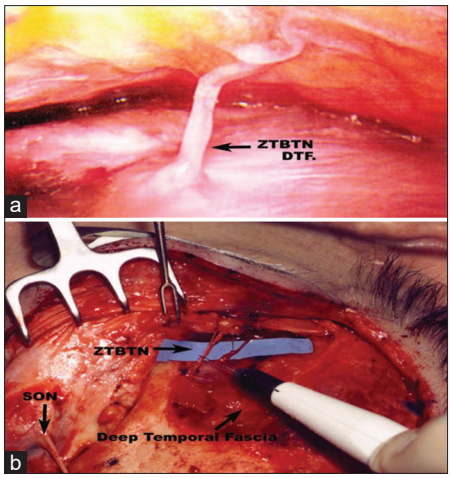

Figure 2: Endoscopic (a) and open (b) view of zygomaticotemporal branch of trigeminal nerve when it pierces the deep temporal fascia

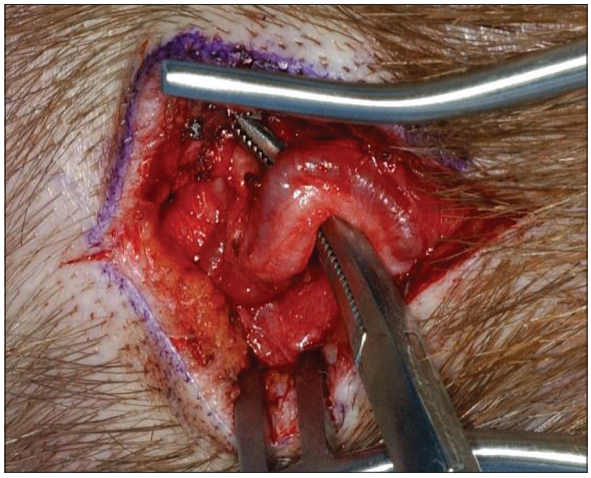

Figure 3: Dissection of the auriculotemporal nerve and superficial temporal artery

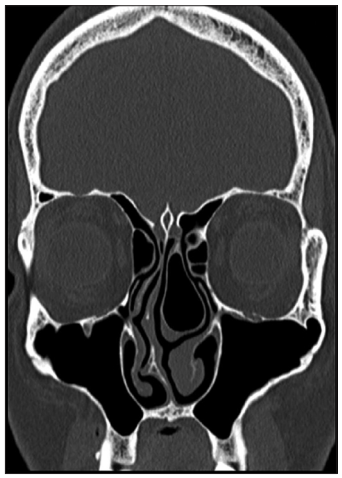

Figure 4: Intranasal CT scan of a patient with sever septal deviation, contact point between septum and right inferior turbinate and left middle turbinate conchae bullosa

as "*occipital neuralgia,*" despite neuralgia having an apparent clear definition as "sudden onset lancinating (electric shock-like) pain" with "abrupt onset and termination." Also based on ICHD-3, the pain of occipital neuralgia is recurring in paroxysmal attacks lasting from a few seconds to minutes. Another differential diagnosis is a cervico-genic headache which sometimes is challenging to distinguish from migraine.[29] If the diagnosis is not clear, we need to proceed with a diagnostic blockade of a cervical structure or its nerve supply. Also, if the diagnosis of migraine is not clear, magnetic resonance imaging (MRI) of the neck and cervical spine is indicated for high-quality visualization of both the cervical spine as well as the surrounding occipital and cervical soft tissues.

Pathophysiology: Greater occipital nerve can be compressed by semispinalis muscle [Figure 5], trapezius fascia, or laterally by the greater occipital artery. The third occipital nerve is more superficial to the greater occipital nerve and it is not consistently found during surgery and is less relevant to the pathophysiology of migraine headache. The Less occipital nerve is more lateral and is found medial to the mastoid tuberosity; this nerve is irritated by local thick fascia and occasionally blood vessels.

Surgical procedure: GON is managed with a midline vertical incision on the caudal occipital region, the trunk of the greater occipital nerve is located approximately 1.5 cm from the midline and 3 cm caudal to the occipital protuberance. At this point, the nerve passes through the semispinalis capitis muscle then travels laterally to pass through the trapezius fascia and then over the greater occipital artery. Deactivation of the trigger site is achieved by removing small pieces of muscle and fascia around the nerve as well as great occipital arteries.

LON is addressed by removing the compression sites over the nerve if the nerve is large or transection of the nerve if the is a smaller nerve.

Recovery and Complication

Most of these procedures are performed at outpatient surgery centers. However, major complications are very rare minor issues like temporary paresthesia and itching in the area of surgery might happen. In rhinogenic trigger points, patients might observe transient nasal dryness.

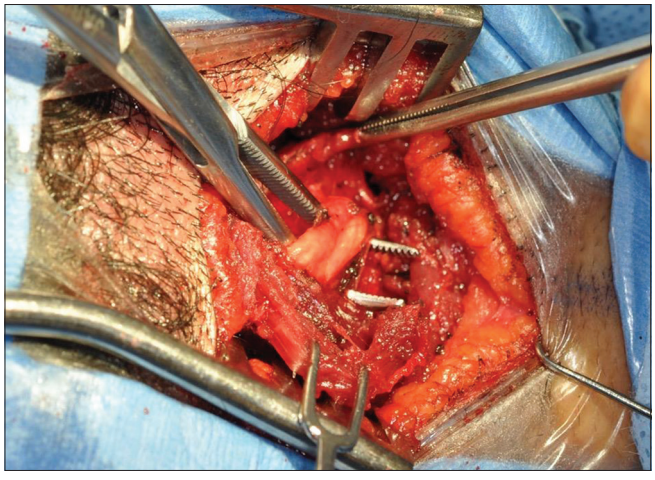

Figure 5: Reater occipital nerve when it passes through semispinalis muscle

Conclusion

Although migraine is a brain disorder, migraine pain can be caused by peripheral mechanisms also in addition to the mechanisms intrinsic to the central nervous system.[30] There is considerable evidence supporting the notion of peripheral etiology as an initiating step in the headache phase of migraine. These studies suggest that migraine is not just a brain disorder but it also involves functional and structural plasticity of both the central and peripheral nervous system.[31] Therefore, it is believed that the complex pathophysiology of migraine involves both the central and peripheral nervous systems.[32]

Do *et al*. described the "bottom-up model" for headache by stating that increased peripheral nociceptive transmission sensitizes the central nervous system to lower the threshold for perceiving pain.[33] This can describe how a peripherally originated pain can affect a brain disorder like a migraine. Therefore, preventing the initiation of the migraine process by *trigger point deactivation* surgery, particularly in patients who do not respond or cannot tolerate traditional migraine treatments can be rewarding.

Patients who present for surgical treatment should have a thorough headache evaluation by a neurologist or a headache specialist. This evaluation will not only help confirm the diagnosis of migraine but also rule out other potential causes or triggers for headache. Furthermore, the thorough evaluation will also assure that the patients have had the appropriate medical treatments before choosing the surgery option. Besides, since patients with chronic migraines have a higher possibility to overuse headache medications, this would need to be investigated and ruled out. Lastly, the trigger sites are identified by reviewing the headache logs, the thorough physical exam, and by the constellation of the symptoms, and in some cases by diagnostic nerve block or CT scan of sinuses. Close collaboration between the headache specialist and the migraine surgery specialist is the key to success in this surgery.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. GBD 2016 Disease and Injury Incidence and Prevalence Collaborators Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195

countries, 1990–2016: A systematic analysis for the Global Burden of Disease Study 2016. Lancet 2017;390:1211-59.
2. Steiner TJ, Stovner LJ, Vos T, Jensen R, Katsarava Z. Migraine is first cause of disability in under 50s: Will health politicians now take notice? J Headache Pain 2018;19:17.
3. Diener HC, May A. New aspects of migraine pathophysiology: Lessons learned from positron emission tomography. Curr Opin Neurol 1996;9:199-201.
4. Weiller C, May A, Limmroth V, Jüptner M, Kaube H, Schayck RV, *et al.* Brain stem activation in spontaneous human migraine attacks. Nat Med 1995;1:658-60.
5. Coppola G, Pierelli F, Schoenen J. Is the cerebral cortex hyperexcitable or hyperresponsive in migraine? Cephalalgia 2007;27:1427-39.
6. Maniyar FH, Sprenger T, Monteith T, Schankin C, Goadsby PJ. Brain activations in the premonitory phase of nitroglycerin-triggered migraine attacks. Brain 2014;137:232-41.
7. Pietrobon D, Moskowitz MA. Pathophysiology of migraine. Ann Rev Physiol 2013;75:365-91.
8. Goadsby PJ, Edvinsson L, Ekman R. Vasoactive peptide release in the extracerebral circulation of humans during migraine headache. Ann Neurol 1990;28:183-7.
9. Goadsby PJ, Holland PR, Martins-Oliveira M, Hoffmann J, Schankin C, Akerman S. Pathophysiology of migraine: A disorder of sensory processing. Physiol Rev 2017;97:553-622.
10. Iyengar S, Johnson KW, Ossipov MH, Aurora SK. CGRP and the trigeminal system in migraine. Headache 2019;59:659-81.
11. Latimer K, Pendleton C, Rosenberg J, Cohen-Gadol AA, Quiñones-Hinojosa A. Dr. Harvey Cushing's attempts to cure migraine based on theories of pathophysiology. J Neurosurg 2011;115:924-8.
12. Guyuron B, Varghai A, Michelow BJ, Thomas T, Davis J. Corrugator supercilii muscle resection and migraine headaches. Plast Reconstr Surg 2000;106:429-34; discussion 435-437.
13. Binder WJ, Brin MF, Blitzer A, Schoenrock LD, Pogoda JM. Botulinum toxin type A (BOTOX) for treatment of migraine headaches: An open-label study. Otolaryngol Head Neck Surg 2000;123:669-76.
14. Guyuron B, Tucker T, Davis J. Surgical treatment of migraine headaches. Plastic Reconstr Surg 2002;109:2183-9.
15. Totonchi A, Pashmini N, Guyuron B. The zygomaticotemporal branch of the trigeminal nerve: An anatomical study. Plastic Reconstr Surg 2005;115:273-277.
16. Mosser SW, Guyuron B, Janis JE, Rohrich RJ. The anatomy of the greater occipital nerve: Implications for the etiology of migraine headaches. Plastic Reconstr Surg 2004;113:693-7; discussion 698-700.
17. Lee M, Brown M, Chepla K, Okada H, Gatherwright J, Totonchi A, *et al.* An anatomical study of the lesser occipital nerve and its potential compression points: Implications for surgical treatment of migraine headaches. Plastic Reconstr Surg 2013;132:1551-6.
18. Janis JE, Hatef DA, Ducic I, Ahmad J, Wong C, Hoxworth RE, *et al.* Anatomy of the auriculotemporal nerve: Variations in its relationship to the superficial temporal artery and implications for the treatment of migraine headaches. Plastic Reconstr Surg 2010;125:1422-8.
19. Caputi CA, Firetto V. Therapeutic blockade of greater occipital and supraorbital nerves in migraine patients. Headache 1997;37:174-9.
20. Guyuron B, Kriegler JS, Davis J. Comprehensive surgical treatment of migraine headaches. Plastic Reconstr Surg 2005;115:1-9.
21. Dirnberger F, Becker K. Surgical treatment of migraine headaches by corrugator muscle resection. Plastic Reconstr Surg 2004;114:652-7.
22. Poggi JT, Grizzell BE, Helmer SD. Confirmation of surgical decompression to relieve migraine headaches. Plastic Reconstr Surg 2008;122:115-22.
23. Guyuron B, Harvey D, Reed D. A prospective randomized outcomes comparison of two temple migraine trigger site deactivation techniques. Plastic Reconstr Surg 2015;136:159-65.
24. Guyuron B, Reed D, Kriegler JS, Davis J, Pashmini N, Amini S. A placebo controlled surgical trial for the treatment of migraine headaches. Plastic Reconstr Surg 2009;124:461-8.
25. Janis JE, Dhanik A, Howard JH. Validation of the peripheral trigger point theory of migraine headaches: Single-surgeon experience using botulinum toxin and surgical decompression. Plastic Reconstr Surg 2011;128:123-31.
26. Liu MT, Armijo BS, Guyuron B. A comparison of outcome of surgical treatment of migraine headaches using a constellation of symptoms versus Botulinum toxin type A to identify trigger sites. Plastic Reconstr Surg 2012;129:413-9.
27. Guyuron B, Riazi H, Long T, Wirtz E. Use of a Doppler signal to confirm migraine headache trigger sites. Plastic Reconstr Surg 2015;135:1109-12.
28. Al-Hashel JY, Ahmed SF, Alroughani R, Goadsby PJ. Migraine misdiagnosis as a sinusitis, a delay that can last for many years. J Headache Pain 2013;14:97.
29. Barmherzig R, Kingston W. Occipital neuralgia and cervicogenic headache: Diagnosis and management. Curr Neurol Neurosci Rep 2019;19:20.
30. Olesen J, Burstein R, Ashina M, Tfelt-Hansen P. Origin of pain in migraine: Evidence for peripheral sensitization. Lancet Neurol 2009;8:679-90.
31. Russo A, Tessitore A, Giordano A, Salemi F, Tedeschi G. The pain in migraine beyond the pain of migraine. J Neurol Sci 2012;33(Suppl 1):S103-6.
32. Charles A. The pathophysiology of migraine: Implications for clinical management. Lancet Neurol 2018;17:174-82.
33. Do TP, Heldarskard GF, Kolding LT, Hvedstrup J, Schytz HW. Myofascial trigger points in migraine and tension-type headache. J Headache Pain 2018;10;19:84.