The Greater Occipital Nerve and Its Dynamic Compression Points: Implications in Migraine Surgery

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Background: The greater occipital nerve is a common compression site for migraine or chronic headache, and variable relationships with the occipital artery have been shown in anatomical studies. Despite surgical decompression, there are still a subset of patients who have an incomplete response. In this article, the authors describe an observed clear and very consistent pattern between the nerve and artery, including both dynamic and static compression points, that must be evaluated for adequate treatment.

Methods: Seventy-one patients underwent occipital nerve decompression with high-definition videos and photographs, and the dynamic relationship between the greater occipital nerve and the occipital artery was recorded in a retrospective review.

Results: A consistent pattern existed in 92 percent of patients, as follows: (1) hidden proximal dynamic compression of the bottom surface of the nerve as the occipital artery comes laterally to dive under the greater occipital nerve; (2) more apparent dynamic compression on the upper surface of the nerve as the occipital artery loops back on top of the greater occipital nerve; (3) intertwining compression after the bifurcation of the greater occipital nerve as the artery wraps around the medial branch; and (4) parallel travel of the terminal branch of the greater occipital nerve with the occipital artery in close proximity.

Conclusions: There is a consistent pattern in the relationship between the greater occipital nerve and the occipital artery after its exit from the trapezius fascia. It is possible that this relationship creates dynamic compression points, including hidden areas, that can only be deactivated by radical excision of the vessel. (*Plast. Reconstr. Surg.* 149: 1321, 2022.)

The etiology of migraines has been classically described as a central nervous system phenomenon.[1] Peripheral mechanisms of migraine genesis have recently gained traction, however. Numerous prospective and retrospective studies show surgical deactivation of peripheral nerves to be safe and effective in reducing migraine symptoms.[2–10] Furthermore, chemical denervation by botulinum toxin injections in peripheral migraine trigger sites is also beneficial for the diagnosis and treatment of severe migraine headaches.[11] The ability to surgically and chemically deactivate problematic nerves supports the theory that peripheral nerve injury at least plays a role in migraine pain. Furthermore, migraines are often described as a pulsatile occurrence. A possible explanation for the pulsating sensation felt by patients is neurovascular compression in areas where the nerve and artery have intimate relationships, such as the greater occipital nerve and occipital artery.[1,12] A cadaveric study by Janis et al. described six potential points of compression that are focused along the greater occipital nerve, including a specific focus where the occipital artery either crosses over the nerve or enters into an intertwining relationship.[13] Although direct histopathological evidence of nerve injury caused by the occipital artery has not been shown yet, clinical evidence and the peripheral theory of nerve sensitization still suggest this relationship as a cardinal factor in pain.[14] Therefore, the rationale behind radical excision of the occipital artery is the potential removal of a source of dynamic

From the University of Texas Southwestern Medical Center.
Received for publication March 23, 2020; accepted August 20, 2021.

DOI: 10.1097/PRS.0000000000009094

Disclosure: *The authors have no conflicts of interest or financial disclosures to report.*

nerve compression along the greater occipital nerve causing subsequent headaches.

In our experience conducting a modified endoscopic approach to occipital decompression, we observed a clear and very consistent pattern in the relationship between the greater occipital nerve and occipital artery after its exit from the trapezius fascia. It is possible that this relationship creates dynamic compression points in hidden areas along the nerve that can only be deactivated by radical excision and lysis of the vessel. A retrospective investigation of intraoperative imaging was carried out to determine the percentage of patients that demonstrated this pattern.

PATIENTS AND METHODS

Between 2013 and 2016, 71 patients underwent site IV migraine surgery performed by the senior author (B.A.). All patients were included in a retrospective intraoperative imaging and chart review. Branching patterns of the greater occipital nerve and occipital artery and any deviations from the usual pattern were recorded. Preoperative topographic locations of tenderness were also noted.

RESULTS

The branching pattern of the greater occipital nerve was documented with photographs and full-length, high-definition videos correlating its dynamic relationship with the occipital artery (Fig. 1). A total of 71 patients who underwent occipital decompression with our modified extended technique were identified. After review, a pattern of four compression sites was seen consistently in almost all cases. This zone of dynamic compression existed 91.5 percent of

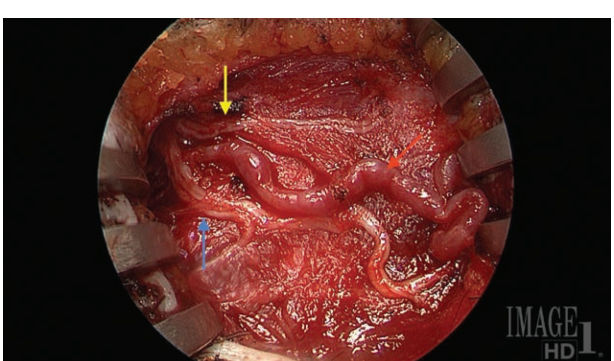

Fig. 1. Distal branching pattern of greater occipital nerve; the *yellow arrow* indicates the medial branch, and the *blue arrow* indicates the lateral branch. The *red arrow* indicates the occipital artery which has been dissected from the greater occipital nerve.

Table 1. Greater Occipital Nerve and Occipital Artery Distal Pattern

	No. (%)
Patients	71
Usual pattern of four compression points	65 (91.5%)
Abnormal distal branching	6 (8.5%)
Two major distal branches	65 (91.5%)
Fewer than 2 major distal branches	6 (8.5%)
Tenderness in topographical area of TGON	71 (100%)

TGON, tail of greater occipital nerve.

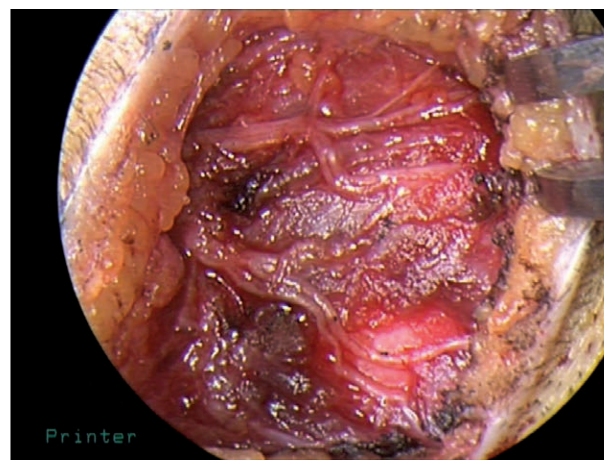

Fig. 2. Aberrant patterns included those with complex and multiple branches of the nerve.

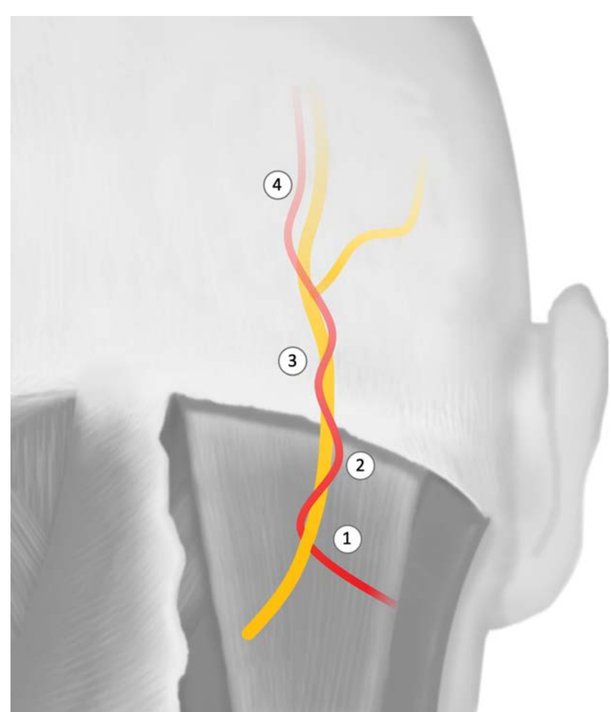

Fig. 3. Anatomy of dynamic compression point of the greater occipital nerve.

the time with slight variations, including size, tortuosity, minor accessory nerves and branching, and minor lateral displacements (Table 1). The majority of nerves had a pathological appearance, including a flat appearance, yellow color, and extensive scarring. Although variation in proximal branching of the greater occipital nerve was seen in seven patients, it is not part of the consistent distal dynamic compression pattern described here. In six patients (8.5 percent), the distal branching of the occipital nerve deviated from the usual pattern and was designated as aberrant. Most of these had complex course with multiple distal branches (Fig. 2).

For the clear majority of cases, there were four possible points of compression (Fig. 3):

1. Hidden proximal dynamic compression of the bottom surface of the nerve as the occipital artery comes laterally to dive under the greater occipital nerve (at the level of or distal to the nuchal line).
2. More apparent dynamic compression on the upper surface of the nerve as the occipital artery loops back on top of the greater occipital nerve.
3. Intertwining compression point after the bifurcation of the greater occipital nerve as the artery wraps around the medial branch.
4. Parallel travel of the terminal branch of the greater occipital nerve with the occipital artery in close proximity.

DISCUSSION

In a 2010 cadaveric study, Janis et al. described a relationship between the greater occipital nerve and occipital artery that intersects 54 percent of the time with two distinct morphologic types: a single intersection point or a helical intertwining.[12] Although that study showed the incidence of various neurovascular relationships among the general population, the review of intraoperative imaging presented here reveals the consistent neurovascular pattern seen in migraine cases. Therefore, we believe that this relationship exists greater than 54 percent of the time in migraine patients. In all but six patients, intraoperative imaging showed that the occipital artery approaches the greater occipital nerve laterally to dive under the nerve, loops back over the top of the nerve, wraps around in an intertwining manner, and finally runs parallel to the medial of two distal greater occipital nerve branches. In addition to the consistent nature of this observation, our review of intraoperative video revealed hidden areas of compression that can only be addressed by radical lysis of the occipital artery. This hidden dynamic compression can be visualized by high-definition endoscopic camera as a pulsation under the greater occipital nerve where an artery is not easily apparent.

In almost all patients, we noticed that the area of maximal tenderness seemed to correlate not only to the previously published (by Janis and Guyuron) exit of the greater occipital nerve from semispinalis capitus muscle but also with the intraoperative topographical location of the vessel and nerve at or between compression point 3 to 4, where the medial bifurcation of the greater occipital nerve intertwines with the occipital artery. This point is well distal to the nuchal line and tight trapezius tunnel and can be appreciated in most patients by palpation medially to the top part of the ear. The peripheral theory of migraine generation involves the close relationship of vasculature to certain nerves including the greater occipital nerve, as in this case, but the exact pathophysiology remains unclear. In patients with higher body mass index, palpation of tenderness can be more difficult, and it does not necessarily need to be done to perform the double incision decompression.

The standard method of greater occipital nerve decompression does not always involve an extensive distal dissection, manipulation, and cauterization of the occipital artery; rather, it is usually cauterization proximally.[15] We believe that our use of endoscope magnification greatly assists in the visualization of dynamic compression points, particularly in instances where the vessel is concealed by soft tissues, fascia, and interposed muscles. This visualization may help prevent excess bleeding during dissection followed by inadvertent cauterization and subsequent nerve damage. Therefore, we believe the role of vessel excision warrants continued investigation.

Our study shows the intimate relationship between the occipital artery and greater occipital nerve. Without distal dissection and ligation of the occipital artery, there is a greater likelihood of decreased therapeutic response to the site IV migraine surgery. Therefore, we advocate for radical lysis of the artery and have not seen longer recovery times. The four compression points described were seen in 91.5 percent of the patients in this chart review and correlated with the described topographical point of tenderness, which suggests that the occipital artery plays a critical role in occipital migraines and chronic headaches.

CONCLUSIONS

In addition to the areas indicated in current literature, we have identified four areas of dynamic compression in the distal greater occipital nerve. Keeping in mind other potential causes of pain in the area, such as the crossing of the nerve over the nuchal ridge and tight fibrous tissue, including the galea and trapezius fascia, the intimate and complex relationship between the greater occipital nerve and the occipital artery here may manifest clinically as a point of maximal tenderness for a number of patients with migraine. Although this anatomical relationship may only be seen in about half the population based on cadaveric studies, it is likely much higher in migraine patients. Addressing these compression points during site IV migraine surgery will result in improved response rates.

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