Anatomical Variations of the Occipital Nerves: Implications for the Treatment of Chronic Headaches

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Background: The anatomy of the greater and lesser occipital nerves has come under increased scrutiny with the increased appreciation of their role in the causation of chronic occipital headaches. Classic anatomical descriptions of their paths have differed from some recent published reports.

Methods: Measurements of the courses of the greater and lesser occipital nerves were conducted bilaterally in 125 individuals, consisting of 112 live intraoperative measurements and 13 cadaver specimens. In addition to nerve width and trajectory in the occiput, measurements of the distance of the nerves from the occipital protuberance were performed.

Results: The greater occipital nerve had a diameter of 3.8 ± 1.6 mm, and emerged from the semispinalis capitis muscle 14.9 ± 4.5 mm lateral to the midline and 30.2 ± 5.1 mm inferior to the occipital protuberance. The nerve almost always (98.5 percent) pierces the body of the semispinalis capitis muscle, and in 6.1 percent of individuals it is split by fibers of this muscle or in the trapezial tunnel. The nerve then travels in a superolateral course. In 43.9 percent of patients, the nerves were asymmetric on the two sides. The lesser occipital nerve had a diameter of 1.2 ± 1.6 mm and was often located along the posterior border of the sternocleidomastoid muscle.

Conclusions: The course of these two nerves differs in several critical aspects from that described in classic anatomical reports. These findings have direct implications for application of nerve blocks and surgical decompression of these nerves. (*Plast. Reconstr. Surg.* 123: 859, 2009.)

The greater and lesser occipital nerves traverse the posterior scalp and neck as dorsal rami of the spinal cervical plexus. Classic anatomical texts describe the nerves' courses as fixed paths that have varied considerably from our experience in surgical exposures and cadaver dissections.[1,2] The clinical relevance of their surgical anatomy has increased drastically over the past several years as surgical decompression of these nerves and preoperative nerve blocks have become used increasingly for the treatment of chronic occipital headaches.

The greater occipital nerve is the medial branch of the posterior division of the second cervical nerve. Its course is described in classic anatomy texts as proceeding between the inferior oblique and the semispinalis capitis muscle in a superomedial fashion. The nerve then crosses above the rectus capitis posterior major muscle and arises medial to the semispinalis capitis muscle, which it occasionally pierces. It then penetrates through the trapezius muscle to join the occipital artery. Along its course, the nerve branches to provide sensory innervation to the skin of the posterior scalp.

The lesser occipital nerve is composed of branches off of the posterior divisions of the second and third cervical nerves. Its path is described as running lateral to the greater occipital nerve, crossing over the sternocleidomastoid muscle, and coursing superolaterally toward the region behind and above the ear. The lesser occipital nerve is depicted as crossing over the sternocleidomastoid muscle quite inferiorly, around the level of the mandibular angle.

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The anatomy of the greater and lesser occipital nerves has been studied by several authors in the past decade as the interest in their contribution to chronic occipital headaches has grown; these authors have made critical refinements to the knowledge of the anatomical courses of these nerves.[3–6] Surgical decompression of the greater and lesser occipital nerves has been suggested as a therapeutic maneuver for the treatment of chronic occipital headaches.[6–9] Preoperative evaluation of these patients can include diagnostic nerve blocks, where local anesthetic agent is injected percutaneously into the presumed location of these nerves.[10,11] With the increased targeting of the greater and lesser occipital nerves in diagnostic and therapeutic strategies, enhanced accuracy and appreciation of the variability of their anatomy can improve treatment results and diagnostic precision.

PATIENTS AND METHODS

Between 2003 and 2008, bilateral measurements of the greater and lesser occipital nerves were recorded in 112 live patients and 13 cadavers. The intraoperative assessments were conducted during surgery on the greater and lesser occipital nerves for chronic occipital headaches, where recording of nerve size, locations, path, distribution, and variations were documented in the operative reports. Bilateral cadaver dissections were performed to analyze the course of the greater and lesser occipital nerves.

Measurements of the location of the nerves were recorded in 1-mm increments as displacement from the anatomical midline, with the maximal palpable point of the occipital protuberance marking the central reference point. Statistical analyses consisted of determination of the mean and SD. This study was approved by the Georgetown University Hospital Institutional Review Board.

RESULTS

Findings from intraoperative measurements of 112 live patients and from 13 cadavers were combined for analysis of greater and lesser occipital nerve anatomy. All patients underwent surgery for occipital neuralgia.

The greater occipital nerve was found to have an average diameter of 3.8 ± 1.6 mm (range, 2.1 to 6.1 mm). As it traverses from its medial origin, it emerges from the semispinalis capitis muscle an average of 14.9 ± 4.5 mm lateral to the midline and 30.2 ± 5.1 mm inferior to the occipital protuberance. The nerve then pierces the fascia of the trapezius muscle 37.8 ± 4.6 mm from the occipital protuberans (range, 24 to 49 mm). In the vast majority of individuals, the greater occipital nerve goes through the body of the semispinalis capitis muscle (98.5 percent); in only 1.5 percent of measurements did the greater occipital nerve traverse medial to the muscle (Fig. 1). While traveling through the semispinalis capitis muscle, in 6.1 percent of individuals, the greater occipital nerve was split by muscle fibers of the semispinalis capitis, with the nerve separating into two branches that would often then reconnect (Fig. 2), and/or the nerve was split within the trapezial tunnel. Once it pierces the semispinalis capitis muscle, the greater occipital nerve consistently travels in an oblique fashion, heading laterally and superiorly across the occiput. Overall, in 56.1 percent of measured individuals, the course of the greater occipital nerve was symmetric between the left and right sides (Fig. 3); in the remaining 43.9 percent, the courses of the nerves were asymmetric.

The lesser occipital nerve was found to have an average diameter of 1.2 ± 1.6 mm. In 85 percent of individuals, it was located along the posterior border of the sternocleidomastoid muscle, at a reference point 3 cm inferior to the occipital protuberance. In the remaining 15 percent, the location varied considerably, ranging from the midsuperficial surface of the sternocleidomastoid muscle to within 1 cm of the greater occipital nerve.

Clinical correlation was generally observed between patient symptoms and intraoperative

Fig. 1. This intraoperative photograph shows normal, symmetric greater occipital nerves on either side of the midline. This surgical exposure further demonstrates the superolateral course of the nerves as they exit from the semispinalis capitis muscles, in contrast to the classic anatomical description of a straight vertical course, just off of the midline.

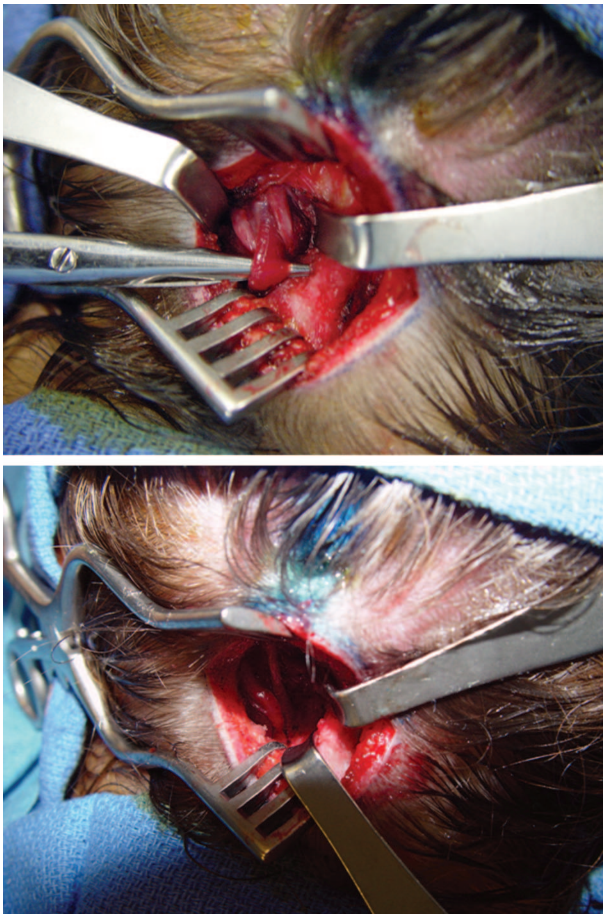

Fig. 2. (*Above*) The greater occipital nerve is split by fibers of the semispinalis capitis muscle, as was found in 6.1 percent of individuals. A bundle of skeletal muscle is found splitting the greater occipital nerve, with the nerve dividing and then reconnecting around the muscle fibers. (*Below*) After the nerve was dissected from the surrounding muscle, it lies decompressed and untethered. The intraoperative photograph demonstrates the greater occipital nerve traversing in a superior direction, with its divided segment free of any intervening muscle.

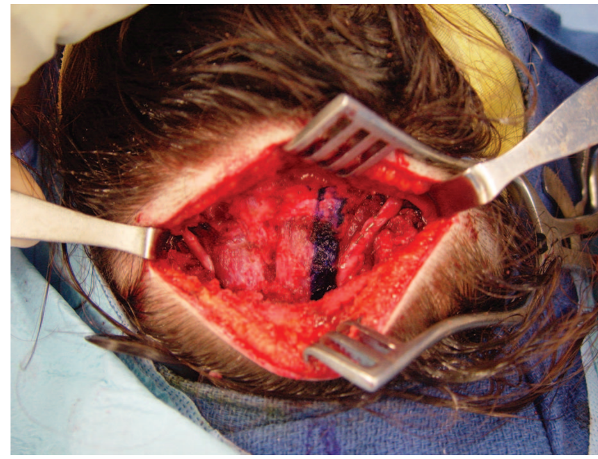

Fig. 3. Markedly asymmetric greater occipital nerve, with the patient's left nerve taking a lateralized course compared with the nerve on the patient's right side.

findings. With increased chronicity of symptoms, the appearance of the nerve tended to lack a fascicular pattern, lack capillary flow on its surface, and have a yellow-brown appearance. These three findings are also observed in other peripheral nerves exposed to chronic compression or trauma.

Measurements were obtained from a reference point at the center of the occipital protuberance for the greater occipital nerve and from the sternocleidomastoid muscle for the lesser occipital nerve. In some patients, the occipital protuberance was poorly defined, and the best estimate of its center was used as the reference point.

DISCUSSION

This study is the largest published report of anatomical measurements and descriptions of the greater and lesser occipital nerves, and provides several insights into anatomical pathways and the incidence of variations. Several major discrepancies exist between the findings of this study and the classic published anatomy[1,2] (Fig. 4). First, the presumed symmetry of the two sides of an individual person is probably not accurate—indeed, we found that over 40 percent of individuals had anatomical asymmetry between the courses of the left and right greater occipital nerves. The critical implication of this finding is that the intraoperative search for the contralateral nerve following identification of the greater occipital nerve on one side should not be limited to the same position on the other side.

A second major discrepancy is that the greater occipital nerve courses medial to the semispinalis capitis muscle, whereas in fact we found that it almost always pierces the muscle. The classic description of the nerve traveling medial to the muscle is in fact found in less than 2 percent of specimens. Furthermore, after penetrating the semispinalis capitis muscle, the greater occipital nerve courses obliquely, in a superolateral fashion. This finding contrasts with the classic presentation of the greater occipital nerve heading directly vertical in a line toward the vertex of the scalp, as is commonly depicted in available anatomy atlases.

Our findings also challenge the established relationships of the greater and lesser occipital nerves with anatomical landmarks. We find that the greater occipital nerve is considerably more

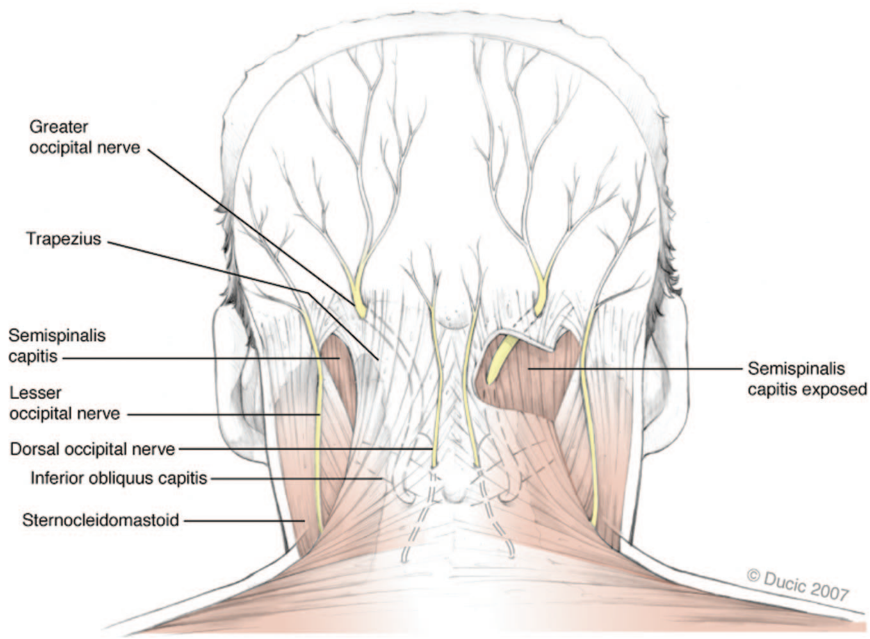

Fig. 4. Schematic illustration of the courses of the greater and lesser occipital nerves as suggested by the most common patterns in our study. Note that the greater occipital nerve pierces the semispinalis capitis muscle and then travels in a superolateral direction. At the level of the occipital protuberance, the greater occipital nerve is approximately 3 to 4 cm lateral to the midline, and the greater and lesser occipital nerves are actually close to each other. Finally, the lesser occipital nerve follows the posteromedial border of the sternocleidomastoid muscle and only crosses it after it has traveled superiorly.

lateral at the level of the occipital prominence and that the greater and lesser occipital nerves often travel closer together than classic anatomical drawings depict. Furthermore, although the lesser occipital nerve does traverse the sternocleidomastoid muscle, it does so in a considerably more superior fashion, often at or above the 3-cm horizontal line below the occipital protuberance.

Multiple previous studies have reported anatomical findings of the greater and lesser occipital nerves, and the majority support the findings described here. In particular, other studies have also found that the greater occipital nerve pierces the semispinalis capitis muscle, travels in a superolateral course, and occasionally splits with intervening soft tissue.[3,4,6,7] Mosser et al. also performed measurements of the greater occipital nerve and found results similar to this study, although the average width of the nerve was slightly less in their report.[7] In earlier studies, Bogduk and Bovim et al. similarly reported the greater occipital nerve in approximately the same location, with respect to the occipital protuberance, as in this study.[3,5] However, as numerous treatment centers attempt to pinpoint the surface anatomy of the ideal location of nerve blocks, the variation in the course of the greater occipital nerve might preclude such uniform nerve block location.[3,4,12] Indeed, our findings suggest that individual treatment failures of nerve blocks for the treatment of occipital headaches could have occurred because the patients might have had anatomical variants such that the nerve block did not hit the nerve.[10,13] In contrast, nerve blocks targeted to "trigger points" where palpation of the presumed nerve triggers tenderness tend to have consistently high success rates.[14–16] Two confounding factors are the precise location of the surface anatomical landmarks, and the nature of the individuals on whom the measurements were performed. First, the occipital protuberance is a palpable bony landmark, not an exact spot, and is even poorly established in some individuals; measurements made to the nearest 1 mm might not be precise. Second, no study to date, including this one, has attempted to distinguish anatomical variations of the greater occipital nerve in patients with, compared with patients without, chronic occipital headaches. Indeed, many of the earlier studies used cadavers without knowledge of any history of chronic occipital headaches; similarly, anatomical reports of surgical findings are uniformly from patients with a history of chronic headaches. Although many of the anatomical variants are shared between the two studied populations, the definitive study would compare anatomical variations in patients with chronic occipital headaches versus those without them.

CONCLUSIONS

The findings reported in this study aim to enhance the appreciation of the location of the greater and lesser occipital nerves, and the variation associated with their anatomical paths. As diagnostic nerve blocks are increasingly being used to evaluate for occipital neuralgia as the cause of a patient's posterior headaches, understanding the courses of the nerves might reduce the incidence of false-negative results or at least diminish the importance of a negative finding on nerve blocks in the setting of an otherwise suggestive clinical examination. Furthermore, as the surgical decompression of these nerves is increasingly being attempted for relief of posterior headaches, heightened awareness of the intricacies of their anatomical paths becomes critical for methodical, meticulous nerve decompression.

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