# RECONSTRUCTIVE

## An Anatomical Study of the Lesser Occipital Nerve and Its Potential Compression Points: Implications for Surgical Treatment of Migraine Headaches

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**Background:** This study maps the course of the lesser occipital nerve and its potential compression sites in the posterior scalp.

**Methods:** Twenty sides of 10 fresh cadaveric heads were dissected. Two fixed anatomical landmarks were used: the y axis was the vertical midline in the posterior scalp through the midline of the cervical spine. The x axis was a horizontal line drawn between the most anterosuperior points of the external auditory meatus. A topographic map of the lesser occipital nerve and its potential compression points was created.

**Results:** The lesser occipital nerve emerged from the posterior border of the sternocleidomastoid muscle at an average of  $6.4 \pm 1.4$  cm lateral to the *y* axis and  $7.5 \pm 0.9$  cm caudal to the *x* axis. Branches of the occipital artery were found to interact with the lesser occipital nerve in 11 of the 20 hemiheads (55 percent). The mean location of the artery-nerve interaction was  $5.1 \pm 0.9$  cm lateral to the *y* axis and  $2 \pm 1.45$  cm caudal to the *x* axis. Two patterns of artery-nerve interaction were seen: a single site of artery crossing over the nerve in nine of 20 hemiheads (10 percent). A fascial band was identified to compress the lesser occipital nerve in four of 20 hemiheads (20 percent).

**Conclusion:** This anatomical study traced the lesser occipital nerve as it courses through the posterior scalp and mapped its potential decompression sites. (*Plast. Reconstr. Surg.* 132: 1551, 2013.)

he cause of occipital and nuchal pain spans a wide spectrum, including whiplash, trauma, prior surgery, and cervical spine abnormalities. Previous studies have identified sensory nerve irritation in the posterior head and neck region as one of the causes of occipital headaches.<sup>1-8</sup> Neural tissue irritation in headaches has been linked to anatomical variants that externally compress peripheral nerves. Various tissues have been proposed as potential "compressors," including bone, fascia, muscles, and arteries.<sup>1,3,4,8</sup> Muscles and arteries have the ability to change anatomical shape following stimulation, and the subsequent changes can cause compression of surrounding structures. Bone

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Copyright © 2013 by the American Society of Plastic Surgeons DOI: 10.1097/PRS.0b013e3182a80721 and fascial bands are thought to potentiate irritation of a swollen nerve because of an unyielding intrinsic nature, much like the transverse carpal ligament in the hand. The focus of migraine surgery has been on the surgical release of peripheral nerves from various compressing structures. The major sensory nerves involved in the occipital region include the greater occipital nerve, the lesser occipital nerve, and the third occipital nerve.<sup>9</sup> Efforts to minimize irritation to these sensory nerves vary and include nerve stimulator implantation, neurolysis, neurectomy, cervical collars, and decompression.<sup>6,10</sup> Despite the varied consensus on treatment modalities, most will agree that a thorough understanding of the course and potential compression sites of these sensory nerves is critical for successful peripheral nerve decompression. Although the course and

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compression sites of the greater occipital nerve have been delineated, the potential compression sites of the lesser occipital nerve remain undiscussed.<sup>1</sup> The purpose of this anatomical study was to provide a topographic map of the lesser occipital nerve course and its potential compression sites in the occipital scalp.

### MATERIALS AND METHODS

Ten fresh cadaver heads were obtained at Case Western Reserve University. Twenty sides of 10 fresh cadaveric posterior heads and necks were dissected to identify the course of the lesser occipital nerve and its potential compression points. After shaving and positioning the heads in the prone position, two permanent landmarks were marked on all heads. The longitudinal axis (y axis) was a vertical line drawn in the posterior midline through the cervical spine. The horizontal axis (x axis) was a line drawn between the most anterosuperior points of the external auditory canals. Using a no. 10 blade, a midline incision was made from the occipital protuberance to the posterior neck. Bilateral skin flaps were raised, exposing the underlying musculature and galea. The occipital artery, lesser occipital nerve, and greater occipital nerve were then identified in this plane. The course of the lesser occipital nerve was traced from its emergence from the posterior edge of the sternocleidomastoid muscle to the subcutaneous scalp. Compression points along its course were noted. The relationship between branches of the occipital artery and the lesser occipital nerve were noted. Vertical and horizontal distances of compression points from the x and y axes were measured in 1-mm increments. Photographs were taken. All data were collected and analyzed using an Excel database (Microsoft Corp., Redmond, Wash.). Descriptive statistics were used.

### RESULTS

The average age of the cadaver heads was 84.2 years (range, 63 to 97 years). Four of the 10 heads were from male cadavers. All heads were dissected bilaterally and yielded 20 sides. The lesser occipital nerve was identified as it emerged from the posterior border of the sternocleidomastoid muscle. No fascial or muscular compression of the lesser occipital nerve was noted at its point of emergence from the sternocleidomastoid muscle. On average, the point of emergence of the lesser occipital nerve was  $6.4 \pm 1.4$  cm lateral to the *y* axis and  $0.5 \pm 0.9$  cm caudal to the *x* axis (Fig. 1.). An intimate relationship between branches of the



**Fig. 1.** The lesser occipital nerve emerging from the posterior border of the sternocleidomastoid muscle. The muscle is retracted.

occipital artery and the lesser occipital nerve was found in 11 of 20 hemiheads (55 percent). The mean location of the artery-nerve interaction was  $5.1 \pm 0.9$  cm lateral to the y axis and  $2 \pm 1.45$  cm caudal to the x axis. Two patterns of artery-nerve interaction were seen: single interaction and helical intertwining (Fig. 2 and Table 1). The single artery-nerve interaction was the most common pattern, and was observed in nine of 20 hemiheads (45 percent). The crossing of the artery over or under the nerve provided a singular point of compression. On average, it was located  $5.07 \pm 1.09$  cm lateral from the y axis and  $2.25 \pm 1.63$  cm caudal to the *x* axis. The helical intertwining relationship between the occipital artery and the lesser occipital nerve occurred in two of 20 hemiheads (10 percent). The midpoint of the helical intertwining complex was located on average  $5.22 \pm 0.68$  cm lateral from the y axis and  $1.57 \pm 1.12$  cm caudal to the x axis (Table 2 and Fig. 3). Among specimens without any vascular/neural interaction, the two structures were observed to run either parallel to or divergent from each other.

In addition to the vascular compression point, a fascial band was identified to compress the lesser

### Table 1. Relationship of the Lesser Occipital Nervewith the Occipital Artery

Relationship	%
Hemiheads with no relationship between the lesser	
occipital nerve and the occipital artery	45
Hemiĥeads with intersecting relationship between	
the lesser occipital nerve and the occipital artery	45
Hemiheads with intertwining relationship between	
the lesser occipital nerve and the occipital artery	10

	Comp Occipital		
	Single Nerve-Artery	Midpoint of the Nerve-Artery	Compression Point 2:
	Intersection	Intertwining Complex	Fascial Band
Distance from the y axis, cm	$5.07 \pm 1.09$	$5.22 \pm 0.68$	$\begin{array}{c} 4.70 \pm 0.81 \\ 1.31 \pm 1.52 \end{array}$
Distance caudal from the <i>x</i> axis, cm	$2.25 \pm 1.63$	$1.57 \pm 1.12$	

Table 2.	Compression	<b>Points along</b>	the Lesser	<b>Occipital Nerve*</b>
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occipital nerve in four of 20 hemiheads (20 percent). The band was located approximately  $4.70 \pm 0.81$  cm lateral from the *y* axis and  $1.31 \pm 1.52$  cm caudal to the *x* axis. Although the band varied in width, all bands were observed to form a tunnel around the lesser occipital nerve (Fig. 4).

### DISCUSSION

The lesser occipital nerve, along with the greater occipital nerve and the third occipital nerve, provides sensation to the occipital scalp. Irritation to this trilogy of sensory nerves has been implicated as one of the causes of occipital head-aches. Consequently, multiple previous studies had scrutinized the anatomical course of these nerves.<sup>11,12</sup>

The lesser occipital nerve arises from the lateral branch of the dorsal rami of the C2 and/ or C3 spinal nerves. Previous anatomical studies traced its emergence at approximately 60 to

70 mm from the midline and 40 to 60 mm inferior to a line drawn between the lowest points of the external auditory canals.<sup>7</sup> Ducic et al. studied the lesser occipital nerve along the posterior border of the sternocleidomastoid muscle in 85 percent of 125 individuals.<sup>12</sup> Our study affirms the anatomical descriptions of the lesser occipital nerve from previous studies. All the lesser occipital nerve were found to exit at the posterior border of the sternocleidomastoid muscle at 5.0 to 7.8 cm lateral to the y axis and 6.6 to 8.4 cm caudal to the x axis. No muscular or fascial compression points were noted at the emergence point of the lesser occipital nerve from the sternocleidomastoid muscle in these 10 cadaver heads. Although previous studies reported the lesser occipital nerve at 4.0 to 6.0 cm caudal to the *x* axis, this discrepancy is attributable to a difference in the position of the x axis.<sup>11,12</sup> This study used a line drawn between the most anterosuperior points of the external auditory canals,



**Fig. 2.** Two different examples of the lesser occipital nerve and occipital artery relationship: intersecting and intertwining. (*Left*) The artery passing over the nerve. The hemostat and *left arrow* are pointing to the artery. (*Right*) The nerve runs parallel to the artery before intertwining with the artery. The *left arrow* points to the nerve, and the *right arrow* points to the artery.



Fig. 3. Graphic representation of identified compression points.

whereas the prior study used a line drawn between the lowest points of the external auditory canal.

Recent studies have recognized the importance of the arterial-neural relationship in relation to peripheral nerve irritation. It is theorized that the pulsatile nature of some migraine headaches may be secondary to vasodilation of arteries intimately associated with peripheral nerves.<sup>13</sup> Shimizu et al. searched for the relationship between the greater occipital nerve and the occipital artery in 12 fresh cadavers. The artery and the nerve were found to cross each other in all specimens.<sup>14</sup> Janis et al. expanded on the work by demonstrating that two types of interactions between the occipital artery and the greater occipital nerve exist: (1) a singular discrete intersection in 29.6 percent of the specimens and (2) an intertwining helix in 70.4 percent of the specimens.<sup>1</sup> Interestingly, the percentage of specimens with the helical intertwining complex (38 percent) was the same as the percentage of surgery suboptimal responders found by the senior author (B.G.) in the occipital region. It is unclear whether or not this is a mere statistical coincidence; perhaps the intertwining nature of the artery contributes more to



**Fig. 4.** Two different examples of the lesser occipital nerve being compressed by a fascial band. (*Left*) A narrow fascial tunnel. The *upper arrow* points to the fascial tunnel and the *lower arrow* points to the nerve. (*Right*) A broad fascial band. The *upper arrow* points to the fascial band and the *lower arrow* points to the nerve.



**Fig. 5.** Summary of compression points and target zone for surgical release.

compression than the single cross pattern. Similar to the greater occipital nerve, this relationship was observed for the lesser occipital nerve. However, unlike the greater occipital nerve, 45 percent of the hemiheads had a singular discrete intersection of the occipital artery and the lesser occipital nerve, and only a minority (10 percent) of the hemiheads demonstrated an intertwining relationship between the occipital artery and the lesser occipital nerve.

In clinical practice, patients who present for lesser occipital nerve decompression are extremely rare. Between 2000 and 2011, eight patients presented to our group for lesser occipital nerve decompression. Seven of eight patients experienced success with the operation (defined as >50 percent reduction in the migraine index) after decompression. The surgical technique began with the patient identifying the area of maximal pain in the preoperative area. The area was then marked. The incision was made directly over the mark and the area was explored for the nerve. Following identification of the nerve, either neurolysis or neurectomy was performed. If the occipital artery was identified to cross the nerve, it was then ligated.

This anatomical study of the fascial bands and arterial interactions with the lesser occipital nerve yielded three unique entities and their respective locations. Combining these along with their standard deviations yields a target area for surgical release that is 3.8 cm vertically and 2.3 cm transversely (Fig. 5). This presents the potential target area for surgical release of the identified compression points.

### CONCLUSIONS

This anatomical study traces the lesser occipital nerve as it courses through the posterior scalp and maps two potential compression sites: (1) vascular compression by the occipital artery located approximately  $5.1 \pm 0.9$  cm lateral from the *y* axis and  $2 \pm 1.45$  cm caudal to the *x* axis, and (2) fascial compression located approximately  $4.70 \pm$ 0.81 cm lateral from the *y* axis and  $1.31 \pm 1.52$  cm caudal to the *x* axis. Although compression of the lesser occipital nerve occurs infrequently, a thorough understanding of its course and compression points will improve the outcomes of occipital headache surgery.

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#### REFERENCES

- Janis JE, Hatef DA, Reece EM, McCluskey PD, Schaub TA, Guyuron B. Neurovascular compression of the greater occipital nerve: Implications for migraine headaches. *Plast Reconstr Surg.* 2010;126:1996–2001.
- Lord SM, Barnsley L, Wallis BJ, Bogduk N. Third occipital nerve headache: A prevalence study. *J Neurol Neurosurg Psychiatry* 1994;57:1187–1190.
- Mosser SW, Guyuron B, Janis JE, Rohrich RJ. The anatomy of the greater occipital nerve: Implications for the etiology of migraine headaches. *Plast Reconstr Surg.* 2004;113:693–697; discussion 698.
- Tubbs RS, Mortazavi MM, Loukas M, et al. Anatomical study of the third occipital nerve and its potential role in occipital headache/neck pain following midline dissections of the craniocervical junction. *J Neurosurg Spine* 2011;15:71–75.
- Guyuron B, Kriegler JS, Davis J, Amini SB. Five-year outcome of surgical treatment of migraine headaches. *Plast Reconstr Surg.* 2011;127:603–608.
- Ducic I, Hartmann EC, Larson EE. Indications and outcomes for surgical treatment of patients with chronic migraine headaches caused by occipital neuralgia. *Plast Reconstr Surg.* 2009;123:1453–1461.
- Tubbs RS, Salter EG, Wellons JC, Blount JP, Oakes WJ. Landmarks for the identification of the cutaneous nerves of the occiput and nuchal regions. *Clin Anat.* 2007;20:235–238.
- Janis JE, Hatef DA, Ducic I, et al. The anatomy of the greater occipital nerve: Part II. Compression point topography. *Plast Reconstr Surg.* 2010;126:1563–1572.
- 9. Netter F. Atlas of Human Anatomy. Summit, NJ: Ciba-Geigy; 1989.
- 10. Slavin KV, Colpan ME, Munawar N, Wess C, Nersesyan H. Trigeminal and occipital peripheral nerve stimulation for

craniofacial pain: A single-institution experience and review of the literature. *Neurosurg Focus* 2006;21:E5.

- 11. Dash KS, Janis JE, Guyuron B. The lesser and third occipital nerves and migraine headaches. *Plast Reconstr Surg.* 2005;115:1752–1758; discussion 1759.
- Ducic I, Moriarty M, Al-Attar A. Anatomical variations of the occipital nerves: Implications for the treatment of chronic headaches. *Plast Reconstr Surg.* 2009;123:859–863; discussion 864.
- Goadsby PJ, Lipton RB, Ferrari MD. Migraine: Current understanding and treatment. N Engl J Med. 2002; 346:257–270.
- 14. Shimizu S, Oka H, Osawa S, et al. Can proximity of the occipital artery to the greater occipital nerve act as a cause of idiopathic greater occipital neuralgia? An anatomical and histological evaluation of the artery-nerve relationship. *Plast Reconstr Surg.* 2007;119:2029–2034; discussion 2035.

