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The role of the third occipital nerve in surgical treatment of occipital migraine headaches☆

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Summary *Background:* The third occipital nerve is often encountered during the occipital migraine surgery, however its contribution to migraine headaches is unclear. The objective of this study was to determine whether removing the third occipital nerve plays any role in the clinical outcomes of occipital migraine surgery.
Methods: A retrospective comparative review was conducted on all occipital migraine headache (Site IV) patients from 1/2000 to 12/2010. Inclusion criteria were: 1) completion of migraine questionnaire, 2) migraine Site IV decompression, and 3) minimum 6 months of follow-up. Patients were divided into those who had the third occipital nerve removed and those who did not. Outcome variables included overall Migraine Headache Index reduction and Site IV pain elimination.
Results: 229 patients met the study inclusion criteria. The third occipital nerve removed group (111 patients) and the third occipital nerve not removed group (118 patients) were comparable in terms of age, gender, number of surgical sites, and statistically well matched regarding preoperative headache characteristics. Comparing the third occipital nerve removed to the third occipital nerve not removed group, Migraine headache index reduction was 63% vs. 64%. Patients experiencing migraine headache elimination (third occipital nerve removed 26% vs. third occipital nerve not removed 29%; $p = 0.45$) and surgery success with at least 50% reduction in migraine headache (third occipital nerve removed 80% vs. third occipital nerve not removed 81%; $p = 0.82$) were also similar. There was also no difference between the two groups in symptomatic neuroma formation. Site IV specific pain elimination was similar between the two groups (third occipital nerve removed 58% vs. third occipital nerve not removed 64%; $p = 0.54$).
Conclusions: Removal of the third occipital nerve did not alter migraine surgery success.

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Introduction

Migraine headache (MH) is a common, costly and debilitating disease process.[1] Treatments of migraine headaches can be subdivided into medical and surgical treatments. First line medical treatments include avoiding potential triggers, Botulinum toxin A injections and utilizing various preventive analgesic and abortive medications.[2,3] Surgical treatment is reserved for patients whose migraines are refractory to medical treatment.[4] Surgical treatment typically involves procedures at four sites: Site I: glabellar muscle group resection in the frontal region, Site II: zygomaticotemporal nerve avulsion in the temporal region, Site III: septoplasty, turbinectomy in the nasal region, and Site IV: greater occipital nerve decompression (GON) in the occipital region.[5,6] The focus of this study is on Site IV.

The GON can be irritated at various points throughout its course along the semispinalis and the trapezius muscles to the subcutaneous tissue of the occipital scalp. The goal of Site IV surgery is to remove potential compression points (muscle, fascia and artery) and decrease GON irritation.[7] The third occipital nerve (TON) is the medial branch of the posterior division of the third cervical nerve. It pierces the trapezius muscle and terminates at the skin at the occipital region close to the midline. Cadaver studies show it can be found 3 mm lateral to the external occipital protuberance with small branches crossing the midline and communicating with the contralateral TON, though anatomic variability does exist.[8] Scant attention has been paid to this nerve and its role in Site IV migraine surgery. At our institution, if this nerve is encountered during the dissection to the GON, it is sacrificed. Preservation of the TON makes it likely to be entrapped in the scar tissue since it often has a long course within the dissected firm fibers of the midline raphe. No additional effort was made to find the TON if it is not readily visualized within the dissected fields. The goal of this study is to determine whether the sacrifice of the TON plays a role in occipital migraine surgery success.

Patients and methods

Institutional review board approval was obtained for this retrospective chart review. Charts for all patients who underwent migraine surgery by the senior author (B.G.) from 2000 to 2010 were reviewed. Study inclusion criteria included: Site IV occipital migraine trigger site decompression and completion of the preoperative and postoperative Migraine Headache Questionnaires. These questionnaires assess the frequency (number of migraines per month), duration (in days), and intensity (based on a visual analog scale from 1 to 10, with 10 being the most severe) of migraine headaches experienced by each patient. All patients had at least six months of post surgical follow up. Patients with missing MH questionnaires and incomplete follow up were excluded. Based on the MH questionnaire, the Migraine Index is calculated with the following formula: Migraine Index (MI) = (MH frequency) $\times$ (MH duration) $\times$ (MH intensity). Success is defined as at least 50% reduction in the MI. In addition to evaluating overall MH occurrence, specific Site IV pain elimination was assessed. Patients were divided into two cohorts, those who had the TON removed and those who did not. Patient information was obtained through a retrospective review of preoperative history and physical. Migraine-specific information was collected from initial and postoperative MH questionnaires. Data obtained included age, sex, MH surgery site, MH frequency, intensity, duration, location and characterization. Statistical analysis was performed using GraphPad Prism 3.02 (GraphPad Software, Inc., La Jolla, Calif.) Statistical analysis of mean values was performed using a two sided *T*-test. Significance was determined by a p value less than 0.05.

Occipital migraine decompression surgical technique

A 4-cm midline incision is designed in hair-bearing caudal occipital region. The incision is taken to the midline raphe, and the trapezius fascia is incised about 0.5 cm lateral to the midline. If the TON nerve is encountered, it is avulsed and allowed to retract into the proximal portion of the semispinalis capitis muscle. The semispinalis capitis muscle and the trapezius muscle are identified. If the trapezius muscle extends to the midline raphe, it is divided and retracted laterally. The semispinalis muscle is then further exposed with the spread of baby Metzenbaum scissors. Dissection continues under the trapezius fascia and muscle laterally until the trunk of the GON is located usually approximately 1.5 cm from the midline and 3 cm caudal to the occipital protuberance. The GON is dissected free from surrounding muscle and fascial bands. The 2 cm long segment of the semispinalis capitis muscle between the nerve and the midline raphe is removed. Any fascial bands overlying the nerve are released until the subcutaneous plane is reached. The occipital artery is ligated when it is entangled with the nerve. A laterally based subcutaneous flap is then elevated and placed deep to the nerve to separate the remaining muscle and nerve. This procedure is then repeated on the opposite side if indicated.[5]

Results

229 patients met the study inclusion criteria. All patients had Site IV decompression. The TON was encountered and removed in 111 patients (TON R), whereas 118 patients did not have the TON removed (TON NR). The TON R and the TON NR cohorts were comparable in terms of age (44.7 vs. 45.3), gender (86.5% female vs. 88.1% female) and number of surgical sites (3.24 vs. 3.26) respectively. See Table 1. In terms of migraine headache characteristics, there were no statistical difference between the two groups in preoperative MH severity (TON R 8.0 vs. TON NR 8.3; $p = 0.35$), MH frequency (TON R 18.1 vs. TON NR 16.1; $p = 0.09$) or MH duration (TON R 0.9 vs. TON NR 1.06; $p = 0.44$). See Table 2. There was no difference in complete overall MH elimination (TON R 26% vs. TON NR 29%; $p = 0.45$) or overall MH surgery success (TON R 80% vs. TON NR 81% group; $p = 0.82$) between the two groups. Assessing Site IV specific pain, there was no difference between the two groups in Site IV

Table 1 Patient characteristics.

	TON-R	TON-NR
Number of patients	111	118
Mean age of patients	44.7	45.3
Percent female	86.5%	88.1%
Mean number of surgical sites	3.24	3.26

pain elimination (TON R 58% vs. TON NR 64%; $p = 0.54$). See Table 3.

TON removed subgroup analysis

Patients with bilateral or unilateral TON removal were also compared. Out of the 111 patients in the TON R group, 53 patients had unilateral TON removal (Unilateral) and 58 patients had bilateral TON removal (Bilateral). These two cohorts of patients were similar in terms of age (Unilateral 43.9; Bilateral 45.5), and number of surgical sites (Unilateral 3.2; Bilateral 3.3). There was no statistical difference between the two groups in preoperative MH severity (Unilateral 8.1 vs. Bilateral 8; $p = 0.90$), MH frequency (Unilateral 18 vs. Bilateral 17.9; $p = 0.78$) or MH duration (Unilateral 1.04 vs. Bilateral 0.82; $p = 0.38$). There was no statistical difference in Site IV specific MH elimination (Unilateral 55% vs. Bilateral 60%; $p = 0.73$), overall MH elimination (Unilateral 22.6% vs. Bilateral 29.3%; $p = 0.24$) or overall migraine surgery success (Unilateral 75.5% vs. Bilateral 84.5%; $p = 0.43$) between the two groups (Table 4).

Discussion

Surgery for MH is based on the theory that a peripheral trigger mechanism plays a cardinal role in triggering migraine headaches. The theory suggests that some migraine headaches are caused by entrapment, compression and/or irritation of sensory nerves in the head and neck.[10] The theory is well supported in the current literature.[4,6,9,11,12]

Previous studies on Site IV migraine surgery have identified multiple muscular, fascial, and vascular compression sites along the GON.[7] Decompression of these potential trigger points along the GON achieves success in migraine index reduction in some but not all of the patients. This spurred investigations into identifying other potential factors that may contribute to persistence pain in this site.[7,13]

The TON is one of the least studied and least understood occipital nerves. Many anatomy textbooks neglect to identify the structure. The TON is the superficial medial branch of the dorsal ramus of C3. It innervates and travels around the C2–3 facet joint. After emerging from the cervical spine, the TON supplies the semispinalis capitis muscle and travels deeply along the muscle before sending a communicating branch to the GON. The TON then exits the overlying trapezius muscle or the fascia and supplies a small area of skin just below the superior nuchal line.[14] TON irritation has been long associated with headaches. Bogduk postulated in 1986 that compression and irritation of the TON by osteoarthritis of the C2-3 zygapophyseal joint could cause headaches. Under fluoroscopic guidance, he injected a local anesthetic at the C2-3 joint in 10 patients. 70% of the patients experienced relief of their headaches after the block.[15] Furthermore Lord et al. found the prevalence of TON related headaches to be as high as 53% in 100 whiplash patients.[16]

We hypothesized that the TON could also be compressed more superficially by the nuchal musculature. The superficial anatomy has been elucidated by various cadaver studies including one by our group. In our study of 20 fresh cadavers the nerve could be found in the region approximately 1.3 cm lateral to midline and 6.2 cm below the level of the external auditory canal (SD 20 mm).[13] In a separate anatomic study Tubbs et al. found the TON approximately 3 mm lateral to the external occipital protuberance with small branches crossing the midline and communicating with the contralateral TON. Variability in location however was present in both studies.

The data presented in this study demonstrates that there is no statistical difference in migraine headache outcomes between the patient cohort who had the TON removed and those who did not. The patients undergoing occipital nerve decompression with or without TON removal were similar regarding age, gender, preoperative migraine frequency, intensity, duration and number of surgical sites. The overall success rate of migraine headache surgery between the two cohorts was similar (80% in the TON R and 81% TON NR, $p = 0.82$). There was no difference in overall MH elimination between the two cohorts (TON R 26% vs. TON NR 29%; $p = 0.45$). Site IV specific pain elimination was also similar between the two groups (TON R 58% vs. TON NR 64%; $p = 0.54$). The TON Removed cohort was then subdivided into patients with either unilateral or bilateral TON removal. No statistical difference was seen between these two cohorts in terms of Site IV pain elimination (Unilateral 55% vs. Bilateral 60%; $p = 0.73$), overall MH success (Unilateral 75.5% vs. Bilateral 84.5%; $p = 0.43$), and overall MH elimination (Unilateral 22.6% vs. Bilateral 29.3%; $p = 0.24$).

Neuroma formation should always be considered when a nerve is avulsed or transected. However, the similarity in Site IV specific pain between patients with no TON removal, unilateral TON removal, and bilateral TON removal suggest that neuroma formation after TON removal did not reach clinical significance.

Table 2 Mean migraine headache characteristics.

		TON-R	TON-NR	p-Value
Preoperative	MH intensity (0–10 scale)	8.0	8.3	0.35
	MH duration (days)	0.9	1.06	0.44
	MH frequency (per months)	18.1	16.1	0.09
	Migraine Index Score	130.3	107.7	0.17
Postoperative	MH intensity (0–10)	4.6	4.5	0.76
	MH duration (days)	0.5	0.46	0.88
	MH frequency (per months)	7.2	7.1	0.83
	Migraine index Score	25.6	27.4	0.79

Table 3 Effect of 3rd occipital nerve removal on migraine surgery success.

	TON-R	TON-NR	*p*-Value
Average migraine headache index reduction	63%	64%	
Percent of patient with overall migraine headache elimination	26%	29%	0.45
Percent of patients with overall migraine surgery success	80%	81%	0.82
Percent of patients with Site IV specific pain elimination	58%	64%	0.54

Table 4 Effect of unilateral, bilateral and no 3rd occipital nerve removal on migraine surgery success.

	Unilateral TON R	Bilateral TON R	*p*-Value
Number of patients	53	58	–
Age of patients	43.9	45.5	–
Number of surgical sites	3.2	3.3	–
Preop MH intensity (0–10 scale)	8.1	8	0.90
Preop MH duration (days)	1.04	0.82	0.38
Preop MH frequency (per months)	18	17.9	0.78
Postop MH intensity (0–10 scale)	5.1	4.1	0.12
Postop MH duration (days)	0.53	0.45	0.70
Postop MH frequency (per months)	7.79	7.0	0.64
Percent of patient with overall migraine headache elimination	22.6%	29.3%	0.24
Percent of patients with overall migraine surgery success	75.5%	84.5%	0.43
Percent of patients with Site IV pain elimination	55%	60%	0.73

An alternative explanation of these results is that in patients where the TON was not found and avulsed, the TON either did not exist or had aberrant anatomy. In a cadaver study by Dash, 10 out of 26 TONs were not found, thus it is unclear whether the TON exists in all patients. Since we did not specifically try to identify the TON, there may have been subgroups of patients that: 1. did not have a TON 2. had a TON with aberrant anatomy 3. had a GON that innervated the same area that would traditionally be innervated by the TON and decompression of the GON in these patients may be equivalent to a functional resolution of the TON trigger point 4. had a TON that was inadvertently dissected. However, considering the large number of patients (118) without TON removal, it is unlikely that all these patients had aberrant or non-existent TON. Also given the senior author's (B.G.) experience with the surgery and knowledge of the anatomy it is unlikely inadvertent transaction of the TON occurred to any appreciable extent.

Based on our data avulsion of the TON during migraine surgery does not improve clinical outcomes. Thus it appears superficial compression of the TON does not contribute significantly to occipital migraine headaches.

Conclusion

Migraine surgery is a rapidly changing field. New trigger sites and compression points are constantly being identified. The third occipital nerve has been associated with cervicogenic headaches, however, based on our data avulsion of the nerve does not have a significant clinical impact on outcomes of migraine surgery.

Statement of conflict of interest/funding

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References

1. Lipton RB, Bigal ME, Diamond M, et al. Migraine prevalence, disease burden, and the need for preventive therapy. *Neurology* 2007;**68**:343–9.
2. Dodick DW. Triptan nonresponder studies: implications for clinical practice. *Headache* 2005;**45**:156–62.
3. Binder WJ, Brin MF, Blitzer A, et al. Botulinum toxin type A (BOTOX) for treatment of migraine headaches: an open-label study. *Otolaryngol Head Neck Surg* 2000;**123**:669–76.
4. Kung TA, Guyuron B, Cederna PS. Migraine surgery: a plastic surgery solution for refractory migraine headache. *Plast Reconstr Surg* 2010;**127**:181–9.
5. Guyuron B, Kriegler JS, Davis J, et al. Comprehensive surgical treatment of migraine headaches. *Plast Reconstr Surg* 2005;**115**:1–9.
6. Guyuron B, Reed D, Kriegler JS, et al. A placebo-controlled surgical trial of the treatment of migraine headaches. *Plast Reconstr Surg* 2009;**124**:461–8.
7. 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**:1563–72.
8. 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**:71–5.

9. Guyuron B, Kriegler JS, Davis J, et al. Five-year outcome of surgical treatment of migraine headaches. *Plast Reconstr Surg* 2010;**127**:603–8.
10. Janis JE, Hatef DA, Reece EM, et al. Neurovascular compression of the greater occipital nerve: implications for migraine headaches. *Plast Reconstr Surg* 2010;**126**: 1996–2001.
11. 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. *Plast Reconstr Surg* 2011;**128**:123–31.
12. Aurora SK, Dodick DW, Turkel CC, et al. OnabotulinumtoxinA for treatment of chronic migraine: results from the double-blind, randomized, placebo-controlled phase of the PREEMPT 1 trial. *Cephalalgia* 2010;**30**:793–803.
13. Dash KS, Janis JE, Guyuron B. The lesser and third occipital nerves and migraine headaches. *Plast Reconstr Surg* 2005;**115**: 1752–8 [discussion 1759–1760].
14. Tubbs RS, Salter EG, Wellons JC, et al. Landmarks for the identification of the cutaneous nerves of the occiput and nuchal regions. *Clin Anat* 2007;**20**:235–8.
15. Bogduk N, Marsland A. On the concept of third occipital headache. *J Neurol Neurosurg Psychiatr* 1986;**49**:775–80.
16. Lord SM, Barnsley L, Wallis BJ, et al. Third occipital nerve headache: a prevalence study. *J Neurol Neurosurg Psychiatr* 1994;**57**:1187–90.