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Clinical outcomes following supraorbital foraminotomy for treatment of frontal migraine headache

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Abstract

Purpose—While 92% of patients who undergo surgical decompression of the supraorbital nerve for treatment of frontal migraine headaches through resection of the glabellar muscle group (GMG) achieve at least 50% improvement, only two thirds demonstrate complete resolution of symptomatology. The purpose of this study was to investigate the role of additional decompression methods by comparing surgery outcomes between patients who underwent supraorbital foraminotomy in addition to glabellar myectomy.

Materials and Methods—Outcome measures including; migraine headache frequency, severity, duration, Migraine Headache Index (MHI), and forehead pain were retrospectively reviewed and statistically analyzed for 43 age-matched control patients who underwent glabellar myectomy for release of the supraorbital nerve and 43 patients who underwent glabellar myectomy with supraorbital foraminotomy from 2002–2010.

Results—The myectomy group (M) statistically matched the myectomy with foraminotomy group (MF) for age, number of surgical sites, and pre-operative headache characteristics ($p > 0.05$). Post-operative migraine frequency per month was 7.8 per month (M) versus 4.1 (MF), severity was 5.6 (M) versus 4.4 (MF), migraine headache index (MHI) was 26.5 (M) versus 11.1 (MF), and persistent forehead pain was 48.8% (M) versus 25.6% (MF). These differences were all statistically significant ($p < 0.05$). Duration of headache was unchanged ($p = 0.17$).

Conclusion—The supraorbital foramen is a potential site of supraorbital nerve compression that can trigger frontal MH. If present, we strongly recommend foraminotomy to ensure complete release of the supraorbital nerve to optimize outcomes. Our results also support consideration of release of any fibrous bands across the supraorbital notch.

Introduction

Migraine headaches (MH) affect approximately 35 million Americans resulting in economic losses that are estimated to exceed \$13 billion annually.^{1–3} Despite optimal preventive and abortive pharmacologic treatment, as many as one-third of MH patients have “refractory” headaches and suffer from persistent symptomatology.^{4–6}

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The improvement in frontal MH symptoms following injection of botulinum toxin into the corrugator supercilii muscles and corrugator muscle resection for periorbital rejuvenation first suggested a possible peripheral etiology of MH.^{7–10} It is theorized that removal of these surrounding anatomic compression points, either surgically or chemically, reduces nerve inflammation and excitability.^{7,8} Subsequent studies have identified three additional common trigger sites including; the zygomaticotemporal nerve (temporal MH), intranasal contact (retrobulbar MH), and the greater occipital nerve (occipital MH). As a result of this discovery a surgical option is now available for patients refractory to standard medical treatment.^{7–9,11–13}

Outcomes of a recent five-year longitudinal study of 69 patients undergoing surgical treatment of MH identified frontal MH as the most commonly reported trigger site (64 patients).¹⁴ While many patients now undergo release of multiple trigger points simultaneously, isolated surgical decompression of supraorbital nerve by myectomy of the glabellar muscle group (GMG - corrugator supercilii, depressor supercilii, lateral procerus) through a palpebral incision performed on 80 patients resulted in a positive outcome for 79 patients (99%). Fifty-one of these patients (64%) reported complete elimination of their symptoms and 28 (35%) reported significant improvement defined as at least a 50% reduction in frequency, duration, or intensity when compared to baseline.⁹ While these results are encouraging, we believe that a partial response following surgical treatment of frontal MH is likely due to an unidentified site of compression.¹⁵

The supraorbital nerve, a sensory branch of the ophthalmic division of the trigeminal nerve, exits the orbit by passing over the supraorbital ridge or via a notch or foramen before diving into a superficial and deep branch and is intimately related to the corrugator supercilii in 78% of patients.^{16–18} While incomplete resection of the GMG may account for persistent MH in some patients, we hypothesize that the supraorbital foramen (present in 25% of patients) may represent an additional compression site.^{19–21} To test this hypothesis we retrospectively reviewed clinical outcomes of 43 control patients who underwent “traditional” glabellar myectomy and 43 experimental patients who underwent myectomy and supraorbital foraminotomy.

Materials and Methods

After approval by our Institutional Review Board we retrospectively reviewed the charts of 43 patients who underwent supraorbital foraminotomy as part of supraorbital nerve release for the treatment of frontal MH from April of 2002 to December 2010 by a single surgeon (BG). If a foramen was identified during dissection a guarded 2-mm osteotome was used percutaneously through the upper eyelid to open the roof of the foramen under direct or endoscopic visualization (Group MF). Clinical outcomes of these 43 patients were compared to 43 controls who underwent traditional resection of the GMG (site I) without foraminotomy (Group M) from the same time period.

All patients were evaluated for MH frequency (number of headaches per month), location, severity (on a scale from 0–10), duration of headaches (days), and Migraine Headache Index (calculated by multiplying frequency, duration, and severity) preoperatively and at one-year follow-up.

Statistical analysis was performed using Prism 3.02 (GraphPad Software, La Jolla, CA). Students T-test was used for comparing headache frequency, duration, migraine index and forehead pain; and the Mann-Whitney test was used for headache severity rating with significance for all analyses defined as $p < 0.05$. Data is expressed as mean $\pm$ standard error.

Results

Patient Characteristics

There was no significant difference in patient gender, age (42.51 ± 1.46 versus 46.67 ± 1.92) or number of trigger sites operated on (3.23 ± 0.12 versus 3.30 ± 0.12) between groups M and MF respectively (Table 1). The distribution of patients undergoing release at multiple sites was also similar for Groups M and MF respectively; single site (1 v. 1), two sites (7 v. 6), three sites (16 v. 15), and four sites (19 v. 21) (Table 2).

Migraine Headache Parameters

Pre- and postoperative migraine history and headache patterns were analyzed for all patients. Preoperatively there was no significant difference in the reported number of headaches per month (Group M = 13.94 ± 1.29 v. Group MF = 13.84 ± 1.37 per month, $p = 0.96$), average duration in days (Group M = 1.21 ± 0.23 v. Group MF = 1.06 ± 1.37 , $p = 0.58$), subjective pain on a scale from zero to ten (Group M = 8.43 ± 0.20 v. Group MF = 8.20 ± 0.29 , $p = 0.96$), or Migraine Headache Index score (MHI) (Group M = 120.30 ± 21.84 v. Group MF = 107.80 ± 15.51 , $p = 0.78$) (Table 3).

At one year follow-up a significant reduction for all parameters analyzed (frequency, duration and pain severity; $p < 0.001$) was seen in all patients ($n = 86$) when compared to preoperative values (Table 4, Figure 1). However, direct comparison of outcomes between the two groups demonstrated a significant improvement in group MF over group M with regard to headache frequency 7.81 per month (-43.98%) v. 4.13 (-70.14%) ($p = 0.022$), severity of pain 5.56 ± 0.44 (-34.03%) v. 4.36 ± 0.42 (-46.82%) ($p = 0.023$), and MHI scores 26.45 ± 6.51 (-78.01%) v. 11.13 ± 2.95 (-89.68%) ($p = 0.008$) (Table 3, Figure 2). The duration of headaches in days for the foraminotomy group was shorter (0.32 ± 0.07 [-69.42%]) when compared to control (0.56 ± 0.15 [-54.06%]), but this difference did not reach statistical significance ($p = 0.17$).

Forehead Pain

All patients were asked to identify specific anatomic sites where they experienced significant pain pre- and postoperatively. Preoperatively a statistically similar number of patient in group M (86.1%), and group MF (81.4%), reported pain above the eyebrows (forehead) and postoperatively a significant reduction in forehead was seen for all patients ($p < 0.001$) (Fig. 3). However, patients in group MF had a statistically greater reduction in forehead pain postoperatively when compared to group M ($p < 0.05$) (Table 3, Figure 3).

Discussion

Since the discovery of improvement in frontal MH following resection of the GMG and the injection of botulinum toxin for periorbital rejuvenation the field of migraine surgery has rapidly evolved.⁷⁻¹³ While studies have demonstrated significant reductions in the postoperative frequency, duration, severity, and Migraine Headache Index, only 64% of patients experienced complete resolution of symptomatology following decompression of the supraorbital nerve for treatment of frontal MH based on site specific analysis. Since these retrospective, pilot, prospective randomized, prospective randomized with sham surgery and long term follow up studies have demonstrated the efficacy, safety and longevity of the results.^{7-10,14} Our team is now focused on improving clinical outcomes.

A thorough understanding of the anatomy of the GMG is essential to ensure complete resection and prevent postoperative complications, whether performing surgery for migraine headaches or forehead rejuvenation.²²⁻²⁵ Cadaveric anatomic studies have described the

dimensions of the corrugator supercilii, its relation to identified bony landmarks, and nerve branching patterns, which should allow for a more aggressive and complete, yet safe, resection.^{18,26} Composed of a transverse and oblique head, which arise from the superomedial aspect of the orbital rim, incomplete lateral resection has been documented, particularly when approached through a transpalpebral incision.²⁷

Whether due to the proximity and interdigitations with the frontalis and orbicularis muscles, concern for damage to the supraorbital nerve, or inadequate understanding of the muscular dimensions, the innervated muscle fibers left after incomplete resection may be one factor that contributes to persistent MH symptoms in the partial responder.²⁸ Failure to resect the entire muscle belly and ensure complete release is likely operator dependent. Reduction in MH symptoms following surgery for periorbital rejuvenation using either an open forehead, endoscopic, or transpalpebral approach by the senior author (BG) did not demonstrate a statistically significant difference by surgical approach; however, the odds ratio for improvement or elimination were highest for the endoscopic group.⁷ A more recent study by our group has clearly demonstrated the superiority of the endoscopic nerve decompression (END) of the supraorbital and supratrochlear nerves over transpalpebral nerve decompression (TPND).²⁹ One of the reasons that we believe the END is superior is the ability to detect and unroof the supraorbital foramen.

In addition to incomplete myectomy, Janis et al. have postulated that the four described branching patterns of the supraorbital nerve that may affect surgical outcomes.¹⁸ In patients with branching patterns I–III (78% of specimens), a portion of the supraorbital nerve, whether the deep or superficial division is intimately related to the corrugator supercilii muscle. The remaining 22% of patients, which correlates closely to the rate of incomplete surgical response (79.5%), demonstrate branching cephalad to the muscle (type IV) without any specific relation to the muscle fibers.^{7,18} Janis et al. propose that this unique anatomical relationship may be responsible for failure to respond after surgical removal of the corrugator. If this is correct it suggests that approximately 20% of patients might have an unidentified supraorbital nerve compression site.

We believe that the additional compression site is related to passage of the supraorbital nerve through the frontal bone via the supraorbital foramen or fascial band across the supraorbital notch as described by Fallucco et al.²¹ Since 2002 the senior author (BG) has performed a supraorbital foraminotomy during release of the supraorbital nerve if encountered during resection of the corrugator. To our knowledge no previous study has assessed the role of foraminotomy on clinical outcomes following surgery for frontal MH.

The supraorbital nerve, a sensory branch of the ophthalmic division of the trigeminal nerve, exits the orbit by passing over the supraorbital ridge or via a notch or foramen.^{16,17} In an anatomic description of the supraorbital ridge by Beer et al. they document five potential configurations for the supraorbital exit point; no notch and no foramen, one or two notches, one or two foramina, medial notch and lateral foramen, medial foramen and lateral notch.²⁰ Of the 1014 orbits from 507 skulls in this study a supraorbital foramen was seen in 273 orbits (26.9%) and is similar to the reported incidence in other studies.^{19–21}

A causal relationship between the presence of a supraorbital foramen and an incomplete surgical response is supported by our current study. Patients who underwent supraorbital foraminotomy demonstrated a significant postoperative reduction in migraine frequency ($p = 0.02$), migraine severity ($p = 0.02$), MHI ($p < 0.01$), and forehead pain postoperatively ($p = 0.03$) at one-year follow-up when compared to controls. One potential confounding factor in the current study is the fact that most patients included in this study underwent simultaneous release at multiple sites. However, there was no statistical difference in the number of

patients undergoing release at multiple sites or the distribution of number of patients by site. Thus, the difference in outcomes is likely related directly to the effect of foraminotomy. Analysis of patients undergoing isolated release of the supraorbital nerve site would eliminate this influence.

Despite the significant improvement in patient outcomes with foraminotomy demonstrated in this study, several control patients without supraorbital foramen continue to suffer from persistent frontal MH despite complete surgical release. One possible explanation for incomplete resolution in patients without a supraorbital foramen is compression by an alternate structure such as the fibrous band that transverses the supraorbital notch. During cadaver studies Janis et al first noted the occasional presence of a fibrous band across the supraorbital notch, anterior to the nerve trunk, which “constrained it against the bony notch ... (and) could potentiate further nerve irritation and/or compression”.¹⁸ This has been supported by a recent cadaver study of 60 supraorbital regions by Fallucco et al. Of the 60 specimens, 50 (83%) had a supraorbital notch and 43 (86%) of specimens with a notch had a fascial band overlying the supraorbital neurovascular bundle that they believe could cause compression proximal to the GMG.²¹

The senior author has since incorporated the release of this supraorbital band during the frontal migraine surgery procedure. Further studies by our group examining whether release of this structure improves clinical outcomes are underway.

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Figure 1. Comparison of pre- and postoperative migraine headache characteristics for all patients (n = 86) at one year follow-up. A significant reduction was seen in all values postoperatively. Mean values ± S.E.M. are shown (***) $p < 0.001$.

Figure 2.

Comparison of pre- and postoperative migraine headache characteristics by group at one year follow-up. Group MF demonstrated a statistically significant improvement in postoperative migraine frequency, severity and migraine index when compared to group M. Mean values $\pm$ S.E.M. are shown (n.s. not significant; * $p < 0.05$; ** $p < 0.01$).

Figure 3.

Comparison of postoperative forehead pain in all patients (left) and by group (right) at one year follow-up. Postoperatively, a statistically significant reduction in forehead pain was seen in all patients when compared to preoperative values (left). Group MF demonstrated a statistically significant decrease in forehead pain postoperatively when compared to group M. Mean values $\pm$ S.E.M. are shown (* $p < 0.05$; *** $p < 0.001$).

Table 1

Patient Characteristics

	M (n = 43)	MF (n = 43)	<i>p</i>
Age	42.51 ± 1.46	46.47 ± 1.92	0.105
Percent Female	97.67%	97.67%	---
Number of Surgical Sites	3.23 ± 0.12	3.30 ± 0.12	0.69

M-Glabellar resection, MF-Glabellar resection with foraminotomy

Table 2

Operative Sites by Group

	M	MF
I, II, III, IV	19 (44.19%)	21 (48.84%)
I, II, III	10 (23.26%)	9 (20.93%)
I, II, IV	5 (11.63%)	6 (13.95%)
I, III, IV	1 (2.33%)	0 (0.00%)
I, II	5 (11.63%)	6 (13.95%)
I, III	1 (2.33%)	0 (0.00%)
I, IV	1 (2.33%)	0 (0.00%)
I	1 (2.33%)	1 (2.33%)
Total	43	43

I-Glabellar, II-Zygomaticotemporal, III-Endonasal, IV-Occipital

Table 3

Comparison of Pre- and Postoperative Headache Characteristics By Group

	Pre-Operative			Post-Operative		
	M	MF	p	M	MF	p
Frequency (Per month)	13.94 ± 1.29	13.84 ± 1.37	0.959	7.81 ± 1.26	4.13 ± 0.94	0.022 *
Severity (0–10)	8.43 ± 0.20	8.20 ± 0.29	0.993	5.56 ± 0.44	4.36 ± 0.42	0.023 *
Duration (Days)	1.21 ± 0.23	1.06 ± 0.16	0.584	0.56 ± 0.15	0.32 ± 0.07	0.167
Migraine Index Score	120.30 ± 21.84	107.80 ± 15.51	0.782	26.45 ± 6.51	11.13 ± 2.95	0.008 ***
% with Forehead Pain	86.05 ± 5.35%	81.40 ± 6.01%	0.565	48.84 ± 7.71%	25.58% ± 6.73%	0.026 *

M-Glabellar resection, MF-Glabellar resection and foraminotomy

*
 $p < 0.05$,***
 $p < 0.01$

Table 4

Postoperative Change in Headache Characteristics (n = 86)

	Pre-Operative	Post-Operative	% Change	<i>p</i>
Frequency (Per month)	13.89 ± 0.93	5.97 ± 0.81	51.66 ± 7.65%	< 0.001
Severity (0–10)	8.32 ± 0.18	4.96 ± 0.31	37.57 ± 4.38%	< 0.001
Duration (Days)	1.14 ± 0.14	0.44 ± 0.08	61.24 ± 11.32%	< 0.001
Migraine Index Score	114.02 ± 13.33	18.79 ± 3.65	83.52 ± 11.10%	< 0.001
% with Forehead Pain	83.72 ± 4.00%	37.21 ± 5.24%	64.60 ± 8.50%	< 0.001