Factors Contributing to Migraine Headache Surgery Failure and Success

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Background: The purpose of this study was to identify factors that contribute to migraine headache surgery failure and success.
Methods: A retrospective chart review was conducted of patients who underwent surgery for migraine headaches performed by the senior author (B.G.) and had at least 11 months of follow-up. The study population included three groups: migraine surgery success, improvement, and failure. Thirty-six unique data points were collected for each patient.
Results: A total of 169 patients met inclusion criteria. Of these, 66 patients comprised the migraine surgery success group (S, complete elimination of migraine headaches); 67 comprised the migraine surgery improvement group (I, >50 percent reduction in migraine frequency, intensity, or duration); and 36 comprised the migraine surgery failure group (F, <50 percent reduction in migraine frequency, intensity, or duration). Significant differences among the groups included age at surgery (S > I, $p = 0.02$), migraine frequency (S < I, $p = 0.02$), age of migraine onset (S > I, $p = 0.003$; S > F, $p = 0.04$), history of head or neck injury (S < I, $p = 0.04$), daily use of over-the-counter migraine medications (S < I, $p = 0.05$), visual symptoms (S > I, $p = 0.02$), increased intraoperative bleeding (S < F, $p = 0.04$; I < F, $p = 0.04$), site I (S > F, $p = 0.0006$; I > F, $p = 0.0004$), site II (S > F, $p = 0.015$), single operative site (S < F, $p = 0.005$), one to two operative sites (S < F, $p = 0.04$; I < F, $p = 0.01$), and four operative sites (S > I, $p = 0.05$; S > F, $p = 0.04$).
Conclusions: Factors associated with migraine surgery failure include increased intraoperative bleeding and surgery on fewer trigger sites. Factors associated with migraine surgery success are older age of migraine onset, higher rate of visual symptoms versus improvement group, surgery at site I or II, and deactivating all four operative sites. (*Plast. Reconstr. Surg.* 128: 1069, 2011.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Risk, III.

Migraine headaches affect over 28 million Americans[1] and approximately 324.1 million people worldwide.[2] They commonly interfere with daily function and are the twentieth leading cause of years lost due to disability around the world.[3] They are also the ninth leading cause of disability in women around the globe.[3]

The most common treatments available for migraine headaches today include a combination of avoidance of common migraine triggers, prophylactic pharmacologic interventions, acute abortive therapy, and acute analgesic therapy. Pharmacologic substances commonly used to treat migraine headache include beta blockers, antidepressants, anticonvulsants, calcium channel blockers, and serotonin antagonists.[4] Although medical therapy provides patients and physicians some control over their migraine headaches, complete elimination of migraine headaches for prolonged periods of time is often not possible. In addition, pharmacologic intervention has numerous side effects and comorbidities, such as fatigue, dizziness, cardiovascular arrhythmias, and hepatotoxicity.[4] Alternative treatment options, such as injections of botulinum toxin type A

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at migraine headache trigger sites, are used to prevent and alleviate migraine headaches. Botulinum toxin type A has been developed and studied over the last decade and works well for a subset of patients.[4]

The current surgical treatment for migraine headaches was first reported by the senior author (B.G.) in 2002, in which he noted patients reporting elimination or improvement of their migraines following forehead rejuvenation surgery.[5] Subsequently, several follow-up studies demonstrating similar results have been published.[6–8] In 2009, a 5-year follow-up study after migraine headache surgery found that 22 percent of patients reported complete elimination of migraines; 62 percent noticed a significant decrease in migraines (defined as a <50 percent reduction in intensity, frequency, or duration of migraines), and only 10 percent experienced no significant change in migraine symptoms following surgery.[9]

Whereas the majority of patients in these studies have shown significant improvement or complete elimination of migraine headaches, a small subset of patients (8 to 16 percent) have experienced a less than 50 percent reduction in frequency, intensity, or duration of their migraines at or past the 1-year postoperative time.[6–9] The purpose of this study was to identify pertinent demographic and clinical factors that may contribute to migraine headache surgery success and failure.

PATIENTS AND METHODS

Inclusion and Exclusion Criteria

After institutional review board approval was obtained, this retrospective cohort study was conducted on patients who had undergone migraine headache surgery performed by the senior author from January 1, 2001, through December 31, 2008. Every patient was examined by a neurologist to confirm the diagnosis of migraine headaches before surgery. Inclusion criteria for the study were patients over the age of 18; surgery at one or more of the four clinically determined common migraine trigger sites; surgery between January 1, 2001, through December 31, 2008; and at least 11 months of follow-up postoperatively.[6,8] The senior author's previously described algorithmic approach to identifying trigger sites was used for all individuals.[5,6,8] The patients were divided into three groups: surgery success, surgery improvement, and surgery failure. Those who reported complete elimination of migraine headaches were assigned to the surgery success group. Those who reported less than 50 percent reduction in migraine frequency, intensity, or duration were in the surgery improvement group. Those who reported less than 50 percent reduction in frequency, intensity, or duration of migraines were included in the surgery failure group. The study exclusion criteria were surgery date outside of the study period, less than 11 months of postoperative follow-up, and additional procedures at one or more surgical sites during the follow-up period.

Data Collection and Variable Analysis

A retrospective chart review was performed. Data collection included demographic information (age at surgery, sex, race, body mass index, smoking history, and general medical and surgical history), migraine-specific information from both preoperative and postoperative questionnaires (frequency, intensity, duration, location, characterization, aura, triggers, and medication use), postsurgical details (location, intraoperative and postoperative complications, recovery room notes, and operative pain control), and postoperative course. For the migraine-specific postoperative data, questionnaires dated 11 to 36 months after surgery were analyzed. If more than one questionnaire was available for this timeframe, then the one dated closest to the 1-year mark was used for data collection. The surgery failure patients' charts were also reviewed for possible explanation for the failure. Specifically, changes in migraine headache site following surgery, anatomic changes after surgery, and/or new head or neck injury were recorded.

Statistical analysis for the study included mean values, analysis of variance, t test, and chi-square analysis using Fisher's exact test and two-tailed p value. A professional biostatistician verified basic analysis and conducted logistic regression and two-way contingency table analysis to further analyze data. Significance was determined by a p value less than 0.05.

Surgical Technique

The operations at each surgical site were performed as previously described.[5,6,8] For patients with frontal headaches (trigger site I), the glabellar muscles, including corrugator supercilii, depressor supercilii, and lateral portion of the procerus, which surround both the supraorbital and supratrochlear nerves, were removed using either a transpalpebral or an endoscopic forehead approach. After removal of the muscles, fat from the medial compartment of the upper eyelid when

the transpalpebral approach was used and from the area above the zygomatic arch during the endoscopic technique was placed around the exposed nerves for protection of the nerve and to fill any defect left by the excised muscles. For patients with temporal headaches (trigger site II), approximately 2.5 cm of the zygomaticotemporal branch of the trigeminal nerve was removed using an endoscopic approach. For patients with migraines originating from the septum (trigger site III), septoplasty and/or turbinectomy was performed based on anatomic abnormalities seen on computed tomographic imaging. For patients with occipital headaches (trigger site IV), a portion of the semispinalis capitis muscle was removed to release the greater occipital nerve bilaterally, with removal of the occipital artery when it was entangled with the nerve. After removal of the semispinalis capitis muscle, a subcutaneous flap was placed to separate the remaining muscle and nerve so that the nerve would be isolated to avoid further irritation or impingement.

RESULTS

A total of 382 patients underwent migraine headache surgery between January 1, 2001, and December 31, 2008, performed by the senior author. One hundred sixty-nine patients met inclusion criteria: 66 experienced complete elimination (S, success group), 67 noted more than 50 percent improvement (I, improvement group), and 37 observed less than 50 percent improvement (F, failure group). The most common reason for patients to be excluded from the study was follow-up less than 1 year postoperatively (Table 1).

Demographic information for patients in the three groups was analyzed. They were well matched with respect to sex, height, weight, body mass index, history of previous plastic surgery or botulinum toxin type A injection, alcohol use, smoking status, and medical history. There was a significant difference between the success and improvement groups with respect to age at surgery ($S > I$, $p = 0.02$; Table 2).

Table 1. Reasons for Exclusion (No. of Patients)

	Surgery Success	Surgery Improvement	Surgery Failure
<11-Month follow-up	19	91	7
Second surgery	1	14	2
Missing data*	1	5	0

*Missing data include missing preoperative migraine questionnaires and missing postoperative follow-up migraine questionnaires.

Patients were well matched with respect to number of regular headaches per month, years suffering from migraine headaches, diagnosis of migraine with aura, and location of migraine headache pain. There was a statistically significant difference between the success and improvement groups with respect to migraines per month ($S < I$, $p = 0.02$); between the improvement and failure (F) groups with respect to pain scale ($I > F$, $p = 0.006$); among all three groups with respect to age of migraine onset ($S > I$, $p = 0.003$; $S > F$, $p = 0.04$); and between the success and improvement groups with respect to history of head or neck injury ($S < I$, $p = 0.04$; Tables 3 and 4). Contingency analysis indicated that the probability of failure of surgery increases if the type of migraine pain is a tight band ($p = 0.02$), whereas the probability of success increases if the discomfort is ache/pressure ($p = 0.04$). Regression analysis indicated that as the length of migraine headache increases, the probability of surgical success increases ($p = 0.02$).

The groups were also well matched in daily prescription migraine medication, daily use of as-needed migraine prescription medication (daily equals >20 times per month), and narcotic use to relieve migraine headache pain. There was a significant difference between the success and improvement groups with respect to daily use of over-the-counter migraine medication ($S > I$, $p = 0.05$; Table 5).

The patient groups reported similar rates of emotional triggers (stress, letdown after stress, or fatigue), physical triggers (heavy lifting, sexual activity, or coughing, bending, and straining), and hormonal triggers (menstrual cycle, hormonal medications, or pregnancy). The groups also reported similar rates of motor symptoms (drooping eyelid, weakness in arms or legs, or speech difficulty). There was a significant difference between the success and improvement groups with respect to visual symptoms (double or blurred vision, sparkling or flashing lights, or loss of vision; $S > I$, $p = 0.02$; Table 6). Contingency analysis indicated a disproportionate number of improvements when there is no lightheadedness associated with migraine headache ($p < 0.0001$). This analysis also indicated patients not sensitive to bright light ($p < 0.0001$) or loud noise ($p = 0.008$) are more likely to have successful surgery.

There was no difference in the frequency of site III and site IV operations among the three groups. There were significant differences with respect to increased intraoperative bleeding ($S < F$, $p = 0.04$; $I < F$, $p = 0.04$), site I surgery location

Table 2. Demographic Information*

Demographic	Surgery Success	Surgery Improvement	Surgery Failure	S versus I (*p*)	S versus F (*p*)	I versus F (*p*)
Female, %	84.8	90.70	75.0	0.44	0.29	0.08
Age, yr	47.1 ± 11.3 (22–75)	42.8 ± 9.0 (20–58)	46.1 ± 9.274 (23–76)	0.02	0.66	0.09
Height, inches	65.0 ± 3.05 (60–75)	65.0 ± 3.27 (58–75)	65.8 ± 3.73 (59–73)	1	0.25	0.26
Weight, lbs	157 ± 30.2 (100–264)	148 ± 25.9 (105–220)	154 ± 34.2 (94–230)	0.07	0.66	0.32
BMI, kg/m^2	25.9 ± 4.50 (17.9–34.7)	24.7 ± 3.9 (18–35.8)	23.4 ± 4.88 (17.8–34.9)	0.1	0.36	0.14
Surgical history, %	18.2	23.20	13.9	0.66	0.78	0.43
Alcohol use, %	28.8	24.20	30.6	0.56	1	0.49
Smoking, %	9.1	18.20	16.7	0.2	0.21	1

S, surgery success; I, surgery improvement; F, surgery failure; BMI, body mass index.
*Data are expressed as mean ± SD (range in parentheses). Surgical history was defined as history of previous plastic surgery or botulinum toxin type A injection (other than for the migraine headache protocol); smoking *p* value was calculated using the chi-square test, with Fisher, one-tailed analysis.

Table 3. Baseline Migraine Headache Data*

	Surgery Success	Surgery Improvement	Surgery Failure	S versus I (*p*)	S versus F (*p*)	I versus F (*p*)
MH per month	8.83 ± 6.04 (1–30)	11.7 ± 7.9 (3–30)	10.3 ± 6.09 (2–30)	0.02	0.25	0.36
Regular HA per month	7.84 ± 11.1 (0–30)	6.1 ± 7.4 (0–30)	6.67 ± 9.14 (0–30)	0.3	0.61	0.73
Pain (0–10 scale)	8.16 ± 1.73 (2–10)	8.46 ± 1.52 (4–10)	7.50 ± 1.84 (3–10)	0.48	0.08	0.006
Years with MH	21.8 ± 12.0 (2–58)	24.1 ± 11.6 (1–52)	25.5 ± 12.3 (3–59)	0.25	0.16	0.57
Age MH started, yr	25.4 ± 11.4 (5–51)	20.0 ± 9.4 (6–46)	20.5 ± 10.3 (3–41)	0.003	0.04	0.8
HX injury, %	15.9	31.3	33.3	0.04	0.08	0.83
Aura, %	43.5	38.1	43.8	0.6	0.43	0.53

S, surgery success; I, surgery improvement; F, surgery failure; HA, headache; MH, migraine headache; HX injury, history of significant head or neck injury; aura, neurologist-documented diagnosis of migraine headache with aura.
*Information was collected for patients' pretreatment migraine headache questionnaires.

Table 4. Location of Migraine Pain per Pretreatment Migraine Headache Questionnaire*

	Surgery Success (%)	Surgery Improvement (%)	Surgery Failure (%)
Behind one eye	24.2	23.90	33.3
Behind both eyes	42.4	46.27	44.4
Not behind eye	33.3	26.90	22.2
One temple	31.8	20.90	36.1
Both temples	42.4	50.70	41.7
Not temple	25.8	25.40	22.2
Above one brow	15.1	20.90	19.4
Above both brows	33.3	44.80	41.7
Not above brows	51.5	31.30	38.9
Back of head one side	13.6	19.40	16.7
Back of head both sides	37.9	38.80	30.6
Not back of head	48.5	37.30	52.8

*Pain behind the eyes corresponds to site III trigger; pain in the temple corresponds to site II trigger; pain above the eye brows corresponds to site I trigger; pain in the back of the head corresponds to site IV trigger.

(S > F, $p = 0.0006$; I > F, $p = 0.0004$), and one to two operative sites (S < F, $p = 0.04$; I < F, $p = 0.01$). There were also significant differences between success and failure with respect to site II surgery location (S > F, $p = 0.01$) and single operative site (S < F, $p = 0.005$) and between success and improvement (S > I, $p = 0.05$) and success and failure (S > F, $p = 0.04$) with respect to four operative sites (Table 7).

DISCUSSION

Surgery success patients had an older age of onset (25.4 ± 11.4 years) compared with surgery improvement (20.0 ± 9.4 years) and surgery failure patients (20.5 ± 10.3 years). The ranges for this data point in particular, however, overlap in such a way that age of onset cannot be used by itself as a screening tool for those who may or may not benefit from surgery. The relationship of migraine headache onset to location of trigger sites and response to surgery is not understood.

The surgery success group had a lower rate of history of significant head or neck injury compared with the other two groups, although this was only significant when comparing the success and improvement groups. In this study, patients reported history of significant head or neck injury, but the exact nature of the injury was not elicited. The patients were not asked to specify whether or not a relationship between the injury and migraine headache onset existed or whether or not there was any change in their migraines following the injury. Prior studies have shown a link between head or neck injury and increased incidence of

Table 5. Migraine Medication Use

	Surgery Success	Surgery Improvement	Surgery Failure	S versus I (*p*)	S versus F (*p*)	I versus F (*p*)
Daily MH prescription medication, %	33.3	43.30	33.3	0.29	1	0.39
Daily use of PRN MH prescription medication, %	13.5	13.40	9.1	1	0.74	0.53
Daily use of OTC MH medication, %	25.8	11.90	11.5	0.05	0.2	1
Narcotic use for MH pain, %	18.2	10.0	8.3	0.13	0.25	1

S, surgery success; I, surgery improvement; F, surgery failure; MH, migraine headache; PRN, pro re nata (as needed); OTC, over the counter.

Table 6. Associated Symptoms and Triggers*

	Surgery Success	Surgery Improvement	Surgery Failure	S versus I (*p*)	S versus F (*p*)	I versus F (*p*)
Visual symptoms, %	65.6	44.8	61.1	0.02	0.67	0.15
Motor symptoms, %	26.6	34.3	44.4	0.45	0.08	0.39
Emotional triggers, %	79.9	77.6	86.1	0.83	0.59	0.43
Sensory triggers, %	82.8	85.1	94.4	0.82	0.13	0.21
Physical triggers, %	25.0	35.8	25.0	0.19	1	0.28
Hormonal triggers, %	51.8	63.5	59.3	0.22	0.64	0.68

S, surgery success; I, surgery improvement; F, surgery failure.
*Visual symptoms include double or blurred vision, sparkling or flashing lights, or loss of vision. Motor symptoms include eyelid drooping, weakness in arms or legs, or speech difficulty. Emotional triggers include stress, letdown after stress, or fatigue. Sensory triggers include bright sun, weather change, loud noise, or certain smells or perfumes. Physical triggers include heavy lifting, sexual activity, or coughing, bending and straining. Hormonal triggers include menstrual cycle, hormonal medication, or pregnancy.

Table 7. Operative Information*

	Surgery Success	Surgery Improvement	Surgery Failure	S versus I (*p*)	S versus F (*p*)	I versus F (*p*)
Increased intraoperative bleeding, %	0.0	0	8.3	1	0.04	0.04
Postoperative complication, %	15.2	11.9	25.0	0.62	0.28	0.1
Site I, %	83.3	83.5	50.0	1	0.0006	0.0004
Site II, %	75.8	61.2	50.0	0.09	0.015	0.3
Site III, %	50.0	49.3	51.5	1	1	1
Site IV, %	45.5	34.3	33.3	0.22	0.29	1
One site operated on, %	24.2	35.8	52.8	0.19	0.0048	0.21
One to two sites operated on, %	50.0	46.3	72.2	0.73	0.04	0.01
Four sites operated on, %	34.7	19.4	8.3	0.05	0.04	0.17

S, surgery success; I, surgery improvement; F, surgery failure.
*Increased intraoperative bleeding was defined as desmopressin acetate needed to stop bleeding.

chronic daily headache[10] in addition to migraine headaches.[11,12] The exact reason why history of head or neck injury leads to increased headaches is unclear.

A higher rate of surgery success and improvement patients had site I and/or site II operative triggers, whereas the surgery failure patients had significantly lower rates of surgery at these trigger sites. Surgery failure group had a higher rate of surgery at only one of the four possible trigger sites when compared with surgery success patients. In addition, surgery failure patients had a significantly higher rate of surgery at one to two trigger sites (versus three to four trigger sites) when compared with surgery success and improvement patients. Conversely, surgery success patients had a significantly higher rate of operation at all four trigger sites compared with both surgery improvement and failure patients. The likely explanation for better outcome associated with greater number of operative locations is that sites of less pain (minor trigger sites) are also targeted as the number of operative locations increases, thus leading to a higher rate of complete elimination of migraine pain. Because sites I and II specifically are more frequent in success and improvement pa-

tients, these locations in particular are likely minor trigger sites and should be considered further in those individuals who report less intense or less frequent pain at these locations.

Surgery failure patients had an 8.3 percent (three of 36 patients) rate of increased intraoperative bleeding requiring desmopressin acetate to stop bleeding, whereas this was not reported in any surgery success or improvement patients. Bleeding was not significant enough to change the procedure and did not interfere with routine completion of the surgery. Although unforeseen bleeding tendencies are not modifiable risk factors, this data point may be most useful in follow-up discussion with patients after surgery. Patients should be aggressively screened for bleeding disorders and intraoperative preventive measures, such as strict blood pressure control, should be implemented to minimize increased bleeding.

Of 36 migraine failure patients, nine patients stated that the site(s) of their migraine headaches postoperatively differed from the operation site(s), although the operative site(s) did correlate to the preoperatively identified migraine pain location. This suggests that all trigger sites were not detected and deactivated in these patients. It is also possible that the initial trigger was incorrectly identified or the primary pain site masked the correct identification of the additional trigger sites. For three patients, anatomic changes were noted in office visit records, including one patient with residual corrugator muscle, one patient with recovery of corrugator muscle, and one patient with frontalis temporalis muscle compression of the supraorbital nerve. Three patients noted recurrent sinusitis during the first postoperative year in the early stages of the authors' experience with this operation, with episodes of sinusitis flare-up correlated with increased migraines. One patient noted a head injury approximately 9 months postoperatively, with increased migraine headaches and change in location of migraine pain following the head injury (Table 8).

Table 8. Explanations for Surgery Failure Patients*

Reason for Failure	No. of Patients
Postoperative MH site different from operative site(s)	9
Anatomic	3
Recurrent sinusitis	3
Head injury	1

MH, migraine headache.
*Anatomic explanations include one patient with temporal muscle compressing supraorbial nerve and two patients with recovery of residual corrugator muscle function following surgery. One patient had significant head injury following surgery and experienced increase migraine frequency after this injury.

In this study, two modifiable factors identified for migraine surgery failure were previously unidentified postoperative trigger sites and recurrent sinusitis. The previously unindentified trigger site(s) was the most common reason for surgery failure. Patients should be evaluated for multiple trigger sites, specifically sites I and II, even if the primary complaint of migraine pain is elsewhere. Antibiotics and intranasal corticosteroids were utilized to minimize sinusitis recurrence soon after the observation was made that this condition could result in delay of recovery or recurrent symptoms and this regimen had eliminated this entity as the reason for the failed results.[13] The reviewed factors and their association with surgical outcome are summarized in Table 9.

Table 9. Summary of Factors and Contributions to Surgical Outcome

Associated with Better Outcome	No Difference	Associated with Worse Outcome
Slightly fewer migraines per month	Sex (male versus female)	History head or neck injury
Older age of migraine onset	Height, weight, BMI	Increased intraoperative bleeding
Daily use of OTC MH medication	Surgical history	Single operative site
Site I and II surgery	Alcohol or tobacco use	One to two operative sites
Four operative sites	Regular headaches per month	
	Years suffering from MH	
	Aura	
	Daily use of MH prescription medication	
	Daily use of PRN MH prescription medication	
	Narcotic use for MH	
	Associated symptoms	
	Associated triggers	
	Postoperative complications	
	Sites III and IV	

BMI, body mass index; OTC, over the counter; MH, migraine headache; PRN, pro re nata (as needed).
Associated with better outcome is linked to surgery success; associated with worse outcome is linked to surgery failure.

CONCLUSIONS

Factors associated with migraine surgery failure include increased intraoperative bleeding and surgery on fewer (one to two) trigger sites. Factors associated with migraine surgery improvement are slightly higher baseline migraine frequency compared with the success group and higher rate of head or neck injury compared with the success group. Factors associated with migraine surgery success are older age of migraine onset, higher rate of visual symptoms versus the improvement group, surgery at site I or II, and deactivating all four operative sites at the same time.

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