Revisiting the Role of Occipital Artery Resection in Greater Occipital Nerve Decompression

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OUTCOMES
Patient-reported Health

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THERAPEUTIC

Background: Greater occipital nerve surgery has been shown to improve headaches caused by nerve compression. There is a paucity of data, however, specifically regarding the efficacy of concomitant occipital artery resection. To that end, the goal of this study was to compare the efficacy of greater occipital nerve decompression with and without occipital artery resection.
Methods: This multicenter retrospective cohort study consisted of two groups: an occipital artery resection group (artery identified and resected) and a control group (no occipital artery resection). Preoperative, 3-month, and 12-month migraine frequency, duration, intensity, Migraine Headache Index score, and complications were extracted and analyzed.
Results: A total of 94 patients underwent greater occipital nerve decompression and met all inclusion criteria, with 78 in the occipital artery resection group and 16 in the control group. The groups did not differ in any of the demographic factors or preoperative migraine frequency, duration, intensity, or Migraine Headache Index score. Postoperatively, both groups demonstrated a significant decrease in migraine frequency, duration, intensity, and Migraine Headache Index score. The decrease in Migraine Headache Index score was significantly greater among the occipital artery resection group than the control group ($p = 0.019$). Patients in both groups had no major complications and a very low rate of minor complications.
Conclusion: Occipital artery resection during greater occipital nerve decompression is safe and improves outcomes; therefore, it should be performed routinely. (*Plast. Reconstr. Surg.* 150: 1091, 2022.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, III.

Migraine is a common neurovascular disease that affects more than a billion individuals worldwide, causing significant patient and societal effects attributable to lost productivity, missed workdays, and overall increased medical costs.[1–3] Migraines are traditionally managed medically by acute analgesic and abortive medications. Although the standard medications alleviate many of the symptoms associated with migraines, there remains approximately one third of migraines that are not adequately ameliorated by these medications.[4]

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Surgical approaches to medically refractory migraines were developed in the early 2000s by Dr. Bahman Guyuron as an alternative option for this patient population.[5–7] These surgeries typically involve peripheral sensory nerve entrapment release from surrounding muscle, bone, fascia, and blood vessels, as well as scar tissue, when applicable.[8] Studies have shown that peripheral nerve surgery is safe and associated with elimination of or significant improvement in symptom frequency, duration, and intensity.[9,10–22]

Patients with headaches in the posterior neck can undergo decompression of the greater occipital nerve. Whereas virtually all greater occipital nerve decompressions involve a release at its entry and exit points of the semispinalis muscle, there is debate regarding the therapeutic benefit of a concomitant occipital artery resection. Anatomical

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studies have found a close relationship between the occipital artery and greater occipital nerve, which provides a potential setting for further interaction with the greater occipital nerve.[23] Chielewksi et al.,[24] however, have shown no statistically significant differences in clinical outcomes between patients who underwent greater occipital nerve decompression with occipital artery resection (when found) and their counterparts who did not undergo occipital artery resection (when not found).[25] Yet, because of the intimate anatomical relationships between these two structures coupled with our improved surgical approaches over the past decade, an updated analysis of the role of occipital artery resection is warranted.

To that end, the goal of this study was to assess whether resection of the occipital artery in patients undergoing greater occipital nerve decompression improved headache surgery clinical outcomes. The results of this study will help provide evidence-based recommendations on the usefulness of occipital artery resection in patients with occipital headaches.

PATIENTS AND METHODS

Participants and Design

This multicenter retrospective cohort study consisted of all patients undergoing greater occipital nerve decompression for occipital migraine headaches who met all inclusion criteria. The inclusion criteria were patients older than 18 years who underwent greater occipital nerve decompression and were followed up for at least 1 year after surgery. Patients were excluded if they did not fully complete the migraine headache questionnaire before the surgery and at 3 and 12 months after surgery. Patients were divided into two groups: patients who underwent greater occipital nerve decompression with occipital artery resection and patients who underwent greater occipital nerve decompression without occipital artery resection (control group). All the procedures and follow-ups were performed by two surgeons (J.E.J. and W.G.A.) from 2015 through 2019. Institutional research board approval was obtained for this study. All procedures performed were in accordance with the initial Declaration of Helsinki and its later amendments or comparable ethical standards. Voluntary consent was obtained from all participants before the surgery.

Surgical Technique

Surgical technique followed what has been published in the literature.[17,20,24] This entailed six-point decompression of the greater occipital nerves through a posterior midline incision with release of the nerve from the obliquus capitus, rectangular segmental resection of the semispinalis between the median raphe and greater occipital nerve, triangular partial resection of the semispinalis lateral to the greater occipital nerve, release of the trapezial tunnel, identification and segmental resection of the occipital artery, and release of the nuchal fascia. As part of the six-point decompression, a local exploration was performed to target the occipital artery for segmental resection or ablation. However, in some patients, despite aggressive approaches to identify the occipital artery, it was not found. In these cases, no counterincisions were made to gain further access to locate it. Rather, as has been found in anatomical studies,[25,26] in some patients, the trajectory of the occipital artery is not in the same surgical vicinity as the greater occipital nerve. In these cases, the occipital artery was not resected and these patients formed the control group.[25,26] Bilateral, three-sided, inferiorly based fat flaps were transposed underneath the decompressed greater occipital nerve, and the skin was closed in layers over a drain. The bilateral third occipital nerves were also identified, ablated, and neurotized into muscle.

Patient Outcomes

Demographic data including age, sex, ethnicity, occupation, and smoking status were extracted from patients' charts. The main outcomes obtained were headache frequency (number of migraines per month), duration (measured in proportion of 24 hours), and intensity (on a scale from 1 to 10). The Migraine Headache Index score was calculated by multiplying these three data points for a maximum score of 300. These data points were obtained at baseline (preoperatively) and postoperatively at 3-month and 12-month follow-up. As per previous literature, a successful surgical outcome was defined as a decrease in score of 50 percent or more, whereas complete migraine elimination was defined as a score of zero at follow-up. Rate of complications was also extracted.

Statistical Analysis

Baseline intergroup differences were assessed using the Fisher exact and independent *t* test for categorical and continuous variables, respectively. Generalized estimating equations were used to assess the efficacy of occipital artery resection on migraine frequency, duration, intensity, and Migraine Headache Index score at 3- and 12-month follow-up. Success and elimination rates

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of occipital artery resection and control groups were compared using the Fisher exact test. All statistical analyses were performed using SPSS 25.0 (IBM, New York, N.Y.). Significance was predetermined and set at $p < 0.05$.

RESULTS

Demographics

A total of 94 patients met all inclusion criteria for this study; 78 patients underwent greater occipital nerve decompression with occipital artery resection and 16 patients in the control group underwent greater occipital nerve decompression without occipital artery resection. The average ages were 49.1 ± 14.3 and 47.5 ± 12.9 years for the former and latter groups, respectively ($p = 0.663$). The large majority of both groups comprised patients who were female, White, nonsmokers, and not working at the time of the initial visit. There were no significant differences in any of the demographic factors between the groups (Table 1).

Surgery Success and Elimination

Of 78 patients who underwent occipital artery resection, 67 (85.9 percent) had successful outcomes (50 percent or more reduction in Migraine Headache Index score) and 32 (41.0 percent) had complete migraine elimination at the 3-month follow-up. In comparison, 11 out of the 16 patients (68.8 percent) in the control group had successful outcomes and four out of the 16 (25.0 percent) had complete migraine elimination at the 3-month follow-up. There was no significant difference in success or elimination rates between the occipital artery resection group and the control group at 3-month follow-up (p = 0.139 and p = 0.271, respectively). In the group who underwent occipital artery resection, 59 out of 78 patients (75.6 percent) had successful outcomes and 25 out of 78 patients (32.1 percent) had complete elimination at 12-month follow-up. In comparison, 11 out of the 16 patients (68.8 percent) in the control group had successful outcome and four out of the 16 patients (25.0 percent) had complete migraine elimination at 12-month follow-up. There was no significant difference in success or elimination rates between the occipital artery resection group and the control group at 12-month follow-up (p = 0.544 and p = 0.768, respectively) (Table 2).

Preoperative and Postoperative Migraine Pain Variables

Migraine Frequency

There were no significant differences in preoperative monthly migraine frequency between the groups (occipital artery resection group: 19.6 ± 9.3; control group: 19.5 ± 9.5; p = 0.972). Compared with baseline, postoperative migraine frequency was shown to have significantly decreased in both the occipital artery resection group (5.3 ± 8.0 at 3 months, 7.1 ± 7.9 at 12

Table 1. Baseline Demographic and Clinical Characteristics of Both Cohorts

Variable	No OA Resection (n = 16)	OA Resection (n = 78)	p
Age, yrs	49.1 ± 14.3	47.5 ± 12.9	0.663
Sex			0.125
Male	5	10	
Female	11	68	
Ethnicity			0.728
White	16	75	
Black	0	1	
Unknown	0	2	
Working status			0.260
Not working	8	27	
Working	7	32	
Unknown	1	19	
Smoking status			0.132
Nonsmoker	11	61	
Past smoker	2	14	
Current smoker	3	3	
Surgical ablation side			<0.001
No ablation	16	0	
Right occipital	0	5	
Left occipital	0	7	
Bilateral occipital	0	66	
Migraine frequency	19.6 ± 9.3	19.5 ± 9.5	0.972
Migraine intensity	7.5 ± 1.2	8.2 ± 1.8	0.174
Migraine duration	0.66 ± 0.41	0.76 ± 0.39	0.333
Migraine headache index	111.8 ± 91.1	120.2 ± 86.9	0.727

OA, occipital artery.

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Table 2. Success and Elimination Rates at 3 and 12 Months Postoperatively for the Occipital Artery Resection Group and the Control Group

Variable	No OA Resection ($n = 16$), n (%)	OA Resection ($n = 78$), n (%)	p
Success at 3 months	11 (68.8)	67 (85.9)	0.139
Elimination at 3 months	4 (25.0)	32 (41.0)	0.271
Success at 12 months	11 (68.8)	59 (75.6)	0.544
Elimination at 12 months	4 (25.0)	25 (32.1)	0.768

OA, occipital artery.

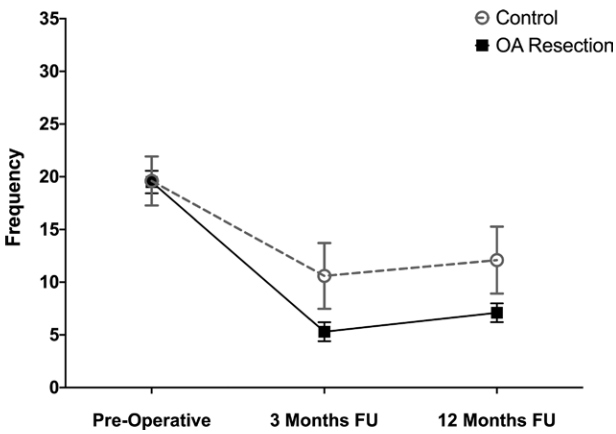

Fig. 1. Migraine frequency preoperatively and at 3 and 12 months postoperatively in the occipital artery (*OA*) resection group and the control group.

months; $p < 0.001$) and the control group (10.6 ± 12.5 at 3 months, 12.1 ± 12.7 at 12 months; $p < 0.001$). There was no significant group–time interaction at the 3-month or 12-month follow-up ($p = 0.184$) (Fig. 1 and Table 3).

Migraine Intensity

There were no significant differences in preoperative migraine intensity between the groups (occipital artery resection group, 8.2 ± 1.8; control group, 7.5 ± 1.2; $p = 174$). Compared with baseline, patients in the occipital artery resection group demonstrated a significant postoperative decrease in migraine intensity both at its 3-month and 12-month follow-up (3.5 ± 3.3 and 4.3 ± 3.3, respectively; $p < 0.001$). A similar effect was seen in patients in the control group, where they experienced a significant decrease in migraine intensity at both 3-month and 12-month follow-up (4.9 ± 3.3 and 5.0 ± 3.4, respectively; $p = 0.002$). There was no significant group–time interaction at the 3-month or 12-month follow-up ($p = 0.109$) (Fig. 2 and Table 3).

Migraine Duration

There were no significant differences in preoperative migraine duration between the groups (occipital artery resection group, 0.76 ± 0.39; control group, 0.66 ± 0.41; $p = 0.333$). Compared with baseline, the resection group exhibited a significant postoperative decrease in duration at its 3-month and 12-month follow-up (0.34 ± 0.55 and 0.41 ± 0.62, respectively; $p < 0.001$). Similarly, patients in the control group experienced a significant decrease in migraine duration at both the 3-month and 12-month follow-up (0.49 ± 0.48 and 0.49 ± 0.45, respectively; $p = 0.011$). There was no significant group–time interaction at both

Table 3. Migraine Frequency, Intensity, Duration, and Migraine Headache Index Preoperatively and at 3 and 12 Months Postoperatively*

Variable	Preoperative	3 Months	12 Months	p
Migraine frequency				
No resection	19.6 ± 9.3	10.6 ± 12.5	12.1 ± 12.7	<0.001
Resection	19.5 ± 9.5	5.3 ± 8.0	7.1 ± 7.9	<0.001
Group–time interaction				0.184
Migraine intensity				
No resection	7.5 ± 1.2	4.9 ± 3.3	5.0 ± 3.4	0.002
Resection	8.2 ± 1.8	3.5 ± 3.3	4.4 ± 3.3	<0.001
Group–time interaction				0.109
Migraine duration				
No resection	0.66 ± 0.41	0.49 ± 0.48	0.49 ± 0.45	0.011
Resection	0.76 ± 0.39	0.34 ± 0.55	0.41 ± 0.62	<0.001
Group–time interaction				0.311
Migraine Headache Index				
No resection	111.8 ± 91.1	71.0 ± 102.8	70.6 ± 98.2	0.002
Resection	120.2 ± 86.9	19.3 ± 44.3	34.0 ± 65.1	<0.001
Group–time interaction				0.019

*Group–time interaction was measured using generalized estimating equations and indicates whether there is a difference between the cohorts across time.

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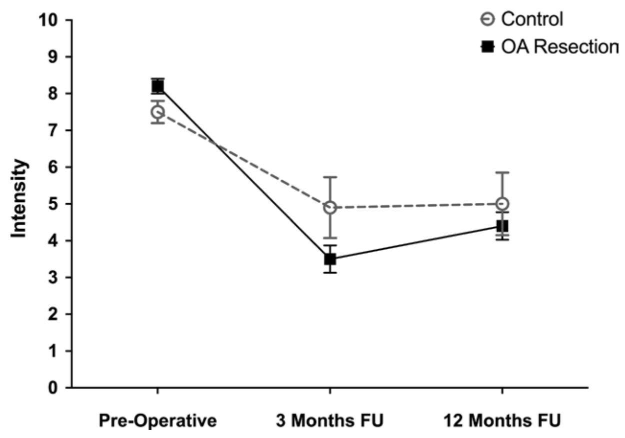

Fig. 2. Migraine intensity preoperatively and at 3 and 12 months postoperatively in the occipital artery (*OA*) resection group and the control group.

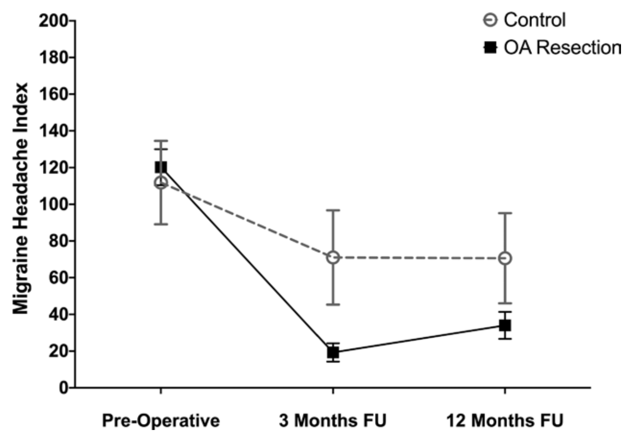

Fig. 4. Migraine Headache Index score preoperatively and at 3 and 12 months postoperatively in the occipital artery (*OA*) resection group and the control group.

3-month or 12-month follow-up ($p = 0.311$) (Fig. 3 and Table 3).

Migraine Headache Index

There were no significant differences in preoperative Migraine Headache Index score between the groups (occipital artery resection group, 120.2.3 ± 86.9; control group, 111.8 ± 91.1; $p = 0.727$). Compared with baseline, postoperative score significantly decreased at the 3-month and 12-month follow-up for both the occipital artery resection group (19.3 ± 44.3 at 3 months, 34.0 ± 65.1 at 12 months; $p < 0.001$) and the control group (71.0 ± 102.8 at 3 months, 70.6 ± 98.2 at 12 months; $p = 0.002$). Moreover, there was a significant group–time interaction ($p = 0.019$), which indicates that the decrease in the Migraine Headache Index score in the occipital artery resection group was significantly larger than the decrease in the control group (Fig. 4 and Table 3).

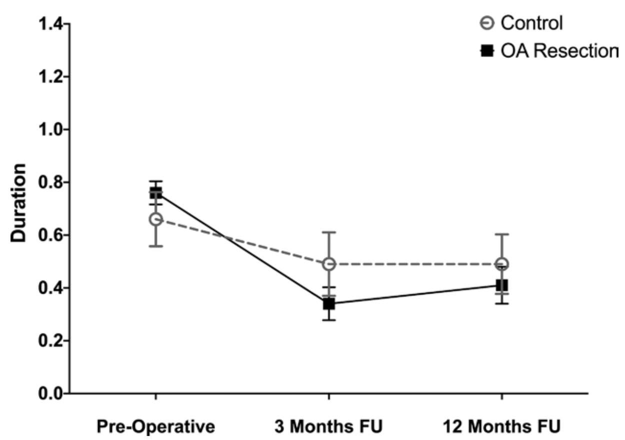

Fig. 3. Migraine duration preoperatively and at 3 and 12 months postoperatively in the occipital artery (*OA*) resection group and the control group.

Complications

There were no major complications reported at follow-up. Six patients had minor complications: two postoperative pruritis, one neuroma, one superficial wound dehiscence, one infection, and one seroma.

DISCUSSION

This study is the first to show that patients undergoing greater occipital nerve decompression for occipital headaches have statistically significantly improved clinical outcomes when undergoing a concomitant occipital artery resection. The exact reason for this incremental improvement is unclear, but our understanding of anatomy and migraine pathophysiology can provide us with plausible hypotheses.

Nerve compression–related headaches can be incited by compression or irritation by surrounding anatomical structures that lead to symptom presentation. One site of potential greater occipital nerve compression is where the occipital artery transverses the nerve. Ducic et al.[27] found a close intraoperative anatomical relationship between the greater occipital nerve and the occipital artery in patients presenting with occipital neuralgia. Moreover, several anatomic studies have confirmed the close proximity of these structures.[26,28–30] Janis et al.[26] highlighted an intimate relationship between the greater occipital nerve and the occipital artery, as they observed a crossover of these structures in more than half of the cadaveric samples they studied. They also showed that the majority of these crossovers represent a complex helical intertwining of the artery with the nerve, which theoretically increases the chance of compression and nerve irritation. Similarly,

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Shimizu et al.[29] reported an indentation in the greater occipital nerve attributable to occipital artery crossover in all their cadaveric specimens. The authors were unable to demonstrate any nerve damage related to that indentation, so it remains unclear whether this causes nerve irritation and, hence, migraine symptoms.

The results of our study contrast some of the previous literature that showed occipital artery resection worsens migraine surgery outcomes. Chmielewski et al.[24] demonstrated how patients who had greater occipital nerve decompression with occipital artery resection had less migraine surgery success and elimination rates compared with their counterparts who did not undergo occipital artery resection. They hypothesized that this effect could be attributable to the formation of extra scar tissue around the greater occipital nerve from the dissection of the occipital artery. However, Chmielewski et al.[24] only preformed an occipital artery resection in patients who had an anatomically close relationship between their greater occipital nerve and occipital artery. This patient selection methodology introduces a bias because these patients might have had worse outcomes regardless of whether they underwent an occipital artery resection or not. Moreover, since the date of that publication, a substantial body of literature has been published, which has helped improve our knowledge of anatomy and surgical approaches related to occipital headache surgery.[31] Improvement in surgical techniques based on better understanding of anatomy could be one of the differentiating factors to explain the difference between our results and those of Chmielewski et al.[24] It is also likely that another factor is the fact that we actively attempted to identify and address the occipital artery/greater occipital nerve interface in every operation, therefore eliminating the selection bias discussed above.

Our study has several limitations. The study was retrospective and nonrandomized. The decision to resect the occipital artery was made based on whether it was in proximity to the greater occipital nerve, and it was specifically targeted for ablation or segmental resection. However, if it was not in the surgical vicinity of the greater occipital nerve, no counterincision was performed to gain increased visualization and the occipital artery was not resected. It is important to interpret our results in this context. Nevertheless, our results strongly demonstrate the benefit of segmentally resecting the occipital artery when identified during greater occipital nerve decompression migraine surgery. Second, our study did not control for any previous trigger site decompression surgery. However, both treatment groups had no statistically different outcomes preoperatively, which further strengthens the conclusion that occipital artery resection leads to better clinical outcomes. Furthermore, the small sample size in the no-resection group could have led to nonsignificant within-group differences; however, we hope that use of the generalized estimating equations model partly helped to rectify this shortcoming. Finally, the study design included patients from two surgeons with extensive experience in peripheral nerve decompression migraine surgery, which limits extrapolating the outcomes to other surgeons with less experience. The study also has several advantages, including the long-term follow-up of all the patients. Moreover, the multicenter nature of the study design improves generalization of the results. Furthermore, both cohorts showed no significant differences in any of the baseline demographic factors, and our use of generalized estimating equations provided parameter estimates and corrected for any external influencers, which strengthens the statistical results.[32]

CONCLUSIONS

This study is the first to demonstrate that occipital artery segmental resection during greater occipital nerve decompression improves surgical outcomes. Furthermore, our study shows that greater occipital nerve decompression with or without occipital artery resection is safe, as evidenced by the low rate of postoperative complications.

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