Surgical Management of Occipital Neuralgia

A Systematic Review of the Literature

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Background: Occipital neuralgia (ON) is a primary headache disorder characterized by severe, paroxysmal, shooting or stabbing pain in the distribution of the greater occipital, lesser occipital, and/or third occipital nerves. Both medical and surgical options exist for treating headaches related to ON. The purposes of this study are to summarize the current state of surgical ON management through a systematic review of the literature and, in doing so, objectively identify future directions of investigation.

Methods: We performed a systematic review of primary literature on surgical management for ON of at least level IV evidence. Included studies were analyzed for level of evidence, therapeutic intervention, study design, sample size, follow-up duration, outcomes measured, results, and risk of bias.

Results: Twenty-two studies met the inclusion criteria. All 22 studies used patient-reported pain scores as an outcome metric. Other outcome metrics included complication rates (7 studies; 32%), patient satisfaction (7 studies; 32%), quality of life (7 studies; 18%), and analgesic usage (3 studies; 14%). Using the ROBINS-I tool for risk of bias in nonrandomized studies, 7 studies (32%) were found to be at critical risk of bias, whereas the remaining 15 studies (68%) were found to be at serious risk of bias.

Conclusions: Greater occipital nerve decompression seems to be a useful treatment modality for medically refractory ON, but further prospective, randomized data are required.

Key Words: occipital neuralgia, occipital headache, occipital migraine, migraine surgery, occipital nerve, nerve decompression, nerve ablation, nerve stimulation, plastic surgery

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Occipital neuralgia (ON) is a primary headache disorder characterized by severe, paroxysmal, shooting, or stabbing pain in the distribution of the greater occipital (GON), lesser occipital (LON), and/or third occipital nerves.[1] Pain can be associated with dysesthesia or allodynia and is often accompanied by tenderness over the affected nerve(s).[1] Careful history taking with an emphasis on the time course and quality of the pain can help to distinguish ON from migraine headache without aura (Table 1).[1] This distinction is significant from the clinical and research perspectives, as ON differs from migraine in both etiology and treatment.[2] It is hypothesized that in ON, compression of the occipital nerves, both extracranial and intracranial, gives rise to symptoms.[3] Several anatomic studies have identified compression points along affected nerves that when decompressed have resulted in abrupt symptom relief.[3–7] Although the etiology of these compression points remains unknown, case series and reports have cited head trauma, whiplash injury or other neck trauma, vascular compression, primary tumors, and local effects of systemic disease as potential sources of compression.[8–10]

Both medical and surgical options exist for treating headaches related to ON. Conservative management includes physiotherapy, cryotherapy, and antiepileptics including carbamazepine.[8,11,12] Procedural options include transcutaneous stimulation, percutaneous nerve blocks, botulinum toxin A injections, and pulsed radiofrequency (PRF).[11,12] Surgically, more invasive techniques including cervical nerve gangliectomy are now rarely performed given the more recently reported success of occipital nerve decompression.[3,13,14]

The multitude of treatment options for ON is reflected by the diverse array of literature on the topic. Despite increasing interest, there has yet to be a comprehensive review of the surgical treatment options for ON management. The purposes of this study are therefore to summarize the current state of surgical ON management through a systematic review of the literature and, in doing so, to objectively identify future directions of investigation.

METHODS

Search Methodology

A systematic review of the current literature on treatment of ON from September 1994 to September 2019 was conducted using the MEDLINE database according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines.[15] Search terms used included "occipital neuralgia," "occipital nerve decompression," "occipital nerve ablation," "occipital neuralgia Botox," "occipital neuralgia abortive treatment," and "occipital neuralgia surgery." Articles were screened for relevance in a stepwise fashion, moving from title to abstract and ultimately to the full text. References from selected articles were additionally queried for other relevant studies.

Selection Criteria

In order to be selected for analysis, articles were required to meet the following inclusion criteria:

1. Original research investigating outcomes after surgical treatment of ON or a meta-analysis of such research
2. Subjects selected exclusively from patients with ON and not another headache disorder as defined by International Classification of Headache Disorders (ICHD-3) criteria[1]
3. Research or meta-analysis including level IV or more robust evidence as defined by the American Society of Plastic Surgeons[16]
4. Full-text article available in English

Importantly, there is a certain degree of heterogeneity in the nomenclature used for ON in the scientific literature. For example, several studies use the term "chronic occipital headache" to describe symptoms that meet ON criteria based on the ICHD-3. As such, when evaluating articles for inclusion based on criteria 2, both the patients' stated diagnosis and defining symptoms were taken into account and studies in

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TABLE 1. Comparison of ICHD-3 Diagnostic Criteria for ON and Migraine Headache Without Aura

Characteristic	ON	Migraine Headache Without Aura
Laterality	Unilateral	Unilateral or bilateral
Duration	Paroxysmal, attacks last seconds to minutes	4–72 h*
Intensity	Severe	Moderate or severe
Quality	Stabbing, shooting, sharp	Pulsatile
Associated symptoms	Tenderness over occipital nerve, allodynia or dysesthesia in response to innocuous scalp stimulation (ie, hair combing)	Nausea, vomiting, photophobia, phonophobia

*Diagnostic duration refers to untreated migraines.

which the defining symptoms were consistent with the ICHD-3 definition of ON were included regardless of the stated diagnosis.

Data Collection and Analysis

Included studies were analyzed for level of evidence, therapeutic intervention, study design, sample size, follow-up duration, outcomes measured, results, and risk of bias. Level of evidence was determined using the American Society of Plastic Surgeons guidelines.[16] Level of bias was determined by 2 of the authors independently using the Risk of Bias In Non-Randomized Studies of Interventions (ROBINS-I) tool.[17] All data analyses were performed using SPSS version 24.0 (IBM, Armonk, New York).

RESULTS

Twenty-two studies met the inclusion criteria (Fig. 1).[11,14,18–38] Two articles[14,32] (9%) presented level II evidence, 1 article[11] (5%) presented level III evidence, and 19 articles[14,18–20,22–31,33–38] (90%) presented level IV evidence. There were no level I articles meeting the inclusion criteria. The number of patients enrolled ranged from 2 to 111, in total capturing 766 patients. Average duration of follow-up ranged from 3 to 67 months. Fifteen studies evaluated interventions on the GON and/or LON (Table 2),[11,14,18–21,23–31] whereas 7 studies evaluated interventions on the C2 nerve root (Table 3).[32–38] Interventions included decompression,[11,14,18–20,22,32–35] ablation (radiofrequency and cryoablation),[23–27,36–38] and stimulation.[28–31] All 22 studies used patient-reported pain scores as an outcome metric. Other outcome metrics included complication rates (7 studies; 32%),[11,24,26,28,33–35] patient satisfaction (7 studies; 32%),[22,25,29,30,35,37,38] quality of life (4 studies; 18%),[18,22,30,37] and analgesic usage (3 studies; 14%).[25,29,31]

Using the ROBINS-I tool for risk of bias in nonrandomized studies, 7 studies (32%)[11,18,20,27,29,30,34] were found to be at critical risk of bias, whereas the remaining 15 studies (68%)[14,19,21,23–26,31–33,36–38] were found to be at serious risk of bias (Fig. 2). Of the 7 factors analyzed with the ROBINS-I tool, the 2 that increased the risk of bias for

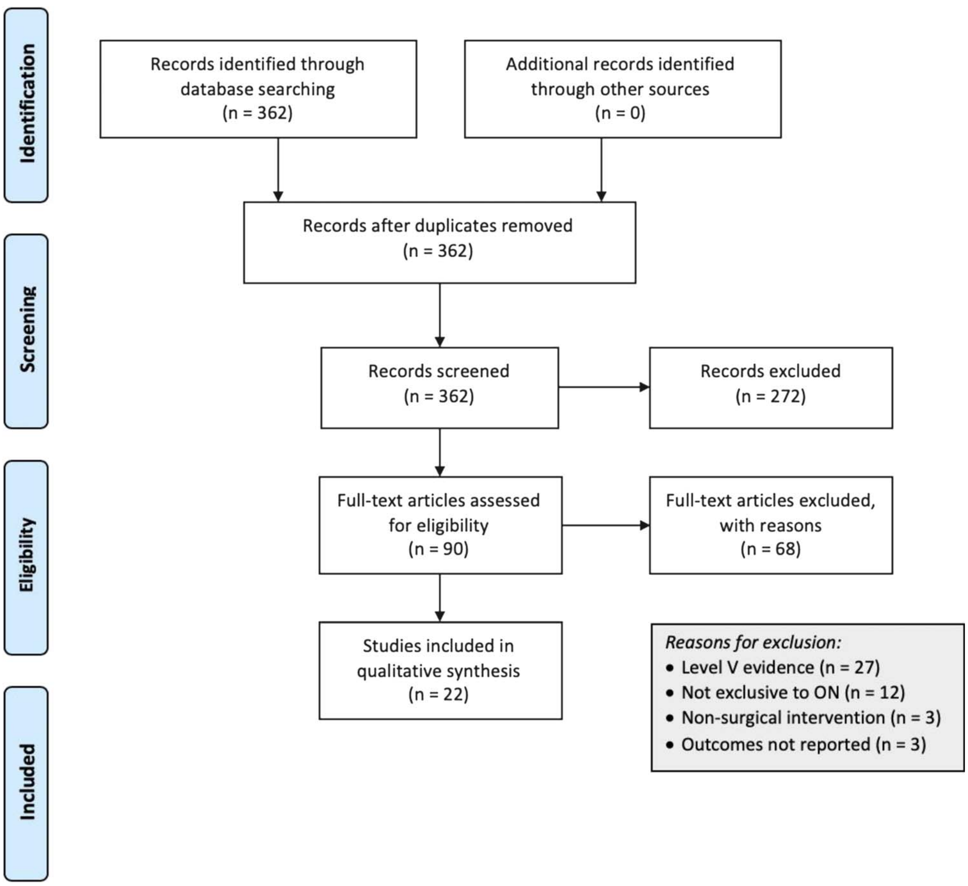

FIGURE 1. Flow diagram for literature search according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. full color online

TABLE 2. ON Interventions Targeting the GON and/or LON

	Title	Authors	Year	LOE	N	Intervention	Follow-Up Duration	Outcomes Measured	Results
Decompressive interventions	Greater occipital nerve decompression for occipital neuralgia	Jose et al[14]	2018	II	11	GON decompression	3–11 mo	Pain severity and frequency	Mean pain episodes decreased from 17.1 ± 5.63 to 4.1 ± 3.51 episodes per month Mean pain intensity decreased from a 7.18 ± 1.33 to 1.73 ± 1.95
	Microsurgical decompression for greater occipital neuralgia	Li et al[19]	2012	IV	76	GON decompression	20 mo	Pain on VAS	Headache symptoms of 68 (89.5%) patients completely resolved and significantly relieved for another 5 (6.6%) 3 patients experienced recurrence of the disorder All experienced hypoesthesia of the GON and recovered within 1 to 6 mo after surgery
	Alternative approach for occipital headache surgery: the use of a transverse incision and W flaps	Afifi et al[18]	2019	IV	71	GON ± LON decompression	8 mo	Migraine headache index Migraine frequency, intensity, duration HIT-6	Average migraine headache index decreased from 191 to 55, with mean improvement of 70% Migraine frequency, intensity, and duration improved by 44.25%, 51%, and 58.4%, respectively Mean HIT-6 score improved from 67 to 57
	Surgical treatment of greater occipital neuralgia by neurolysis of the greater occipital nerve and sectioning of the inferior oblique muscle	Gille et al[25]	2004	IV	10	GON neurolysis and inferior oblique sectioning	Unspecified	Pain on VAS Use of analgesics Degree of patient satisfaction	Anatomic anomalies seen in 3 cases Mean VAS score was 80/100 before surgery and 20/100 at last follow-up Use of analgesics decreased in all patients 7 of 10 patients were satisfied/very satisfied with operation
	Tracking patients with chronic occipital headache after occipital nerve decompression surgery: a case series	Blake et al[20]	2019	IV	7	GON, LON decompression	Unspecified	Pain relief Headache frequency	Complete lasting relief in cases of new daily persistent headache and chronic posttraumatic headache Partial relief of chronic headache/migraine in some cases but no relief of episodic or chronic migraine, or chronic tension-type headache in others
	The treatment of occipital neuralgia: review of 111 cases	Finiels and Batifol[11]	2016	III	111	GON radiofrequency ablation vs Botox injection vs GON stimulation	6 mo	Symptomatic cure rate Complications	Symptomatic cure in 50% of the PRF group vs 62.2% in the Botox group (P = 0.669) vs 80% in the stimulation group (low n precluded comparison) 2 severe complications (1 death, 1 permanent hemiplegia) in PRF group, no severe complications in other groups

	Greater occipital nerve excision for occipital neuralgia: refractory to nerve decompression	Ducic et al[22]	2014	IV	71	GON excision	33 mo	Migraine headache index Migraine disability assessment Satisfaction with surgery Quality of life changes	Success rate was 70.4%, and 41% of patients showed a 90% or greater decrease in migraine headache index 63% average reduction in MHI Migraine disability assessment scores decreased by an average of 49% Diagnosis of cervicogenic headache was associated with failure of surgery Most common adverse effect (seen in up to 31% of patients) was numbness or hypersensitivity in denervated area
Ablative interventions	Treatment of f occipital neuralgia by thermal radiofrequency ablation	Hoffman et al[23]	2018	IV	44	GON radiofrequency ablation	Unspecified	Difference in pain score by VAS Percent pain relief Length of pain relief	Significant difference between preprocedure and postprocedure pain scores Mean pain relief was 76.3% ± 25.0% Mean length of relief was 6.5 ± 5.1 mo
	Cryoablation for the treatment of occipital neuralgia	Kim et al[24]	2015	IV	38	GON cryoablation	12 mo	Pain score on VAS Pain relief percentage Duration of relief Complications	Average improvement of pain relief with CA was 57.9% with average duration of 6.1 mo Percentage and duration of relief significantly improved in those reporting at least 75% relief with local anesthetic injections No significant improvement found in men, but significance in percentage and duration of relief in women with at least 75% benefit with local anesthetic Average pain score improved from 8 on VAS to 4.2 at 6 mo 3 cases of adverse effects (postprocedure neuritis, hematoma)
	Greater occipital nerve cryoneurolysis in the management of intractable occipital neuralgia	Kastler et al[26]	2018	IV	6	GON cryoablation	3 mo	Pain severity by VAS Complications	More than 50% pain reduction achieved at day 7 in all cases, and 5 of 6 cases at 1- and 3-mo follow-up
	Ultrasound-guided greater occipital nerve blocks and pulsed radiofrequency ablation for diagnosis and treatment of occipital neuralgia	Vanderhoek et al[27]	2013	IV	2	GON radiofrequency ablation	Unspecified	Pain relief	Both patients reported immediate, significant pain relief sustained over several months
Stimulating interventions	Occipital nerve stimulation for the treatment of refractory occipital neuralgia: a case series	Keifer et al[28]	2017	IV	29	GON stimulation	Unspecified	Pain severity Complications	Overall success rate of 85%. Average pain score decreased from 7.4 ± 1.7 to 2.9 ± 1.7 4 patients experienced complications (infection, hardware erosion, loss of effect, and lead migration)

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TABLE 2. *(Continued)*

Title	Authors	Year	LOE	N	Intervention	Follow-Up Duration	Outcomes Measured	Results
Peripheral neurostimulation for treatment of intractable occipital neuralgia	Slavin et al[29]	2006	IV	14	GON stimulation	22 mo	Overall satisfaction with pain relief Frequency of medication use	Stimulation was beneficial for at least 6 mo in all implanted patients 7 patients (70%) with continued benefit from treatment at last follow-up
Peripheral nerve stimulation for the treatment of occipital neuralgia and transformed migraine using a C1-2-3 subcutaneous paddle style electrode: a technical report	Oh et al[30]	2004	IV	10	GON stimulation	Unspecified	Pain relief Quality of life Willingness to repeat procedure	At 1-mo follow-up, 17 patients reported excellent relief (>90% reduction), 3 reported good relief (75%–90% reduction) At 6-mo follow-up, 14 reported continued excellent pain relief, 2 reported good relief, 1 reported fair relief (50%–75% pain reduction), and 1 reported poor pain relief (<50% reduction) 19 patients (95%) reported improved quality of life and would undergo procedure again
Occipital nerve stimulation for intractable occipital neuralgia: an open surgical technique	Magown et al[31]	2009	IV	7	GON stimulation	17.7 mo	Pain on VAS Medication consumption	96% mean reduction of pain on VAS Postoperative VAS was 0 in all but 1 patient Nearly all patients discontinued use of analgesics

CA indicates cryoablation; HIT-6, Headache Impact Test.

TABLE 3. ON Interventions Targeting the Cervical Spinal Nerves

	Title	Authors	Year	LOE	N	Intervention	Follow-Up Duration	Outcomes Measured	Results
Decompressive interventions	Distraction arthrodesis of the C1–C2 facet joint with preservation of the C2 root for the management of intractable occipital neuralgia caused by C2 root compression	Yeom et al[32]	2015	II	23	C1–C2 distraction vs fusion	12 mo	Pain on VAS score Neck disability index score Japanese Orthopedic Association score	No significant difference in VAS score between groups preoperatively (8.2 ± 0.9 vs 7.9 ± 0.6) VAS score significantly lower in the distraction group at 1, 3, and 6 mo
	Long-term outcome and prognostic factors after C2 ganglion decompression in 68 consecutive patients with intractable occipital neuralgia	Choi et al[33]	2015	IV	68	C2 decompression	31.3 mo (18–68 mo)	Pain (measured by VAS and also by assigning into 4 categories) Medication use Therapeutic success (pain relief by at least 50% without drugs) Complications	VAS score significantly decreased between preoperative and most recent follow-up At 1 y, positive results in 57 patients (83.9%), but poor in 11 patients (16.1%) Therapeutic success at 5 y in 47 patients (69.1%) Longer duration of headache (>13 y) and retro-orbital/frontal radiation) significantly associated with poor prognosis
	Surgical treatment of greater occipital neuralgia: an appraisal of strategies	Stechison and Mullin[34]	1994	IV	5	C2 decompression vs ganglionectomy	24 mo	Pain relief Complications	All patients had immediate complete relief of pain after surgery 1 patient had recurrence of pain after 26 mo after decompression and required bilateral C2 ganglionotomy All patients experienced transient nausea and dizziness after surgery 1 patient had an incisional CSF leak
	Long-term outcomes of intradural cervical dorsal root rhizotomy for refractory occipital neuralgia	Gande et al[35]	2016	IV	75	Cervical dorsal root rhizotomy	67 mo	Change in symptoms Patient satisfaction Complications	Full pain relief in 35 patients (64%), partial relief in 11 (20%), and no relief in 7 (16%) at last follow-up Extent of relief not significantly associated with ON etiology 21 patients (57%) reported improved activity level/functional state after surgery, 5 (13%) reported a decline, and 11 (30%) reported no difference Acute complications were infections in 9% and CSF leaks in 5% Chronic complications were neck pain/stiffness in 16% and upper extremity symptoms (trapezius weakness, shoulder pain, arm paresthesia) in 5%
Ablative interventions	Microsurgical C2 ganglionectomy for chronic intractable occipital pain	Lozano et al[36]	1998	IV	39	C2 ganglionectomy	28 mo	Pain on VAS Pain relief (excellent, good, or failed)	19 patients had excellent results (>90% reduction in pain) Pain caused by trauma or described as shock-like, electric, shooting, jabbing, stabbing, sharp, or exploding responded best to ganglionectomy (80% good or excellent response) Most patients with nontraumatic pain or described as pounding aching throbbing, or pressure-like did not achieve favorable results

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TABLE 3. *(Continued)*

Title	Authors	Year	LOE	N	Intervention	Follow-Up Duration	Outcomes Measured	Results
Salvage C2 ganglionectomy after C2 nerve root decompression provides similar pain relief as a single surgical procedure for intractable occipital neuralgia	Pisapia et al[37]	2012	IV	29	Immediate vs salvage C2 ganglionectomy	67 mo	Headache relief rating (excellent, good, and poor) Pain on VAS Patient satisfaction, disability, and quality of life	66% experienced good/excellent outcome at most recent follow-up Patients undergoing decompression, ganglionectomy, or decompression followed by ganglionectomy experienced similar outcomes, with mean pain reduction ratings of 5 ± 4.0, 4.5 ± 4.1, and 5.7 ± 3.5, respectively
Pain relief after cervical ganglionectomy (C2 and C3) for the treatment of medically intractable occipital neuralgia	Acar et al[38]	2008	IV	20	C2 ± C3 ganglionectomy	42.5 mo	Pain relief and relief duration Functional status Medication usage Procedure satisfaction	Average VAS scores decreased from 9.4 to 2.6 95% of patients reported short-term relief (<3 mo) Pain returned in 65% of patients after an average of 12 mo (C2) and 8.4 mo (C3)

CSF, cerebrospinal fluid.

the greatest number of articles were the method of outcomes measurement followed by confounding variables. Regarding outcomes, 2 of the included articles were found to be at critical risk of bias, whereas the remaining 20 articles were found to be at serious risk of bias. In this context, *critical risk* refers to studies in which outcomes between the 2 groups are different enough to preclude meaningful comparison, whereas *serious risk* refers to studies in which the outcomes measured were subjective (ie, pain improvement). Regarding confounding, 5 articles were found to be at critical risk, 4 at severe risk, and 12 at moderate risk of bias. Here *critical risk* refers to study designs in which confounding is inherently not controllable, *serious risk* refers to studies in which attempts to control for confounders are expected to be insufficient, and *moderate risk* refers to studies in which attempts to control for confounders are expected to sufficiently account for serious confounders.

GON and/or LON Intervention

Every treatment targeting the named occipital nerves fell into 1 of 3 categories: decompression, ablation, and stimulation. Five articles investigated decompression.[14,18–20,25] In the highest level of evidence study from this group, Jose et al[14] demonstrated that GON decompression decreased mean ON pain intensity from 7.18 ± 1.33 to 1.73 ± 1.95. Six articles studied ablation, including radiofrequency ablation and cryoablation.[11,21,23,24,26,27] In the largest of these studies, a series of 111 patients found that PRF had a cure rate of 50% compared with 62.2% in the Botox group ($P = 0.669$).[11] In this series, PRF was associated with 2 major complications: 1 death and 1 permanent hemiplegia. Four articles reported outcomes from GON stimulation.[28–31] The largest series in this group found an overall success rate of 85%, with an average visual analog scale (VAS) score decreased from 7.4 ± 1.7 to 2.9 ± 1.7.[28]

Cervical Spinal Nerve Intervention

Interventions involving the cervical spinal nerves include decompressive and ablative techniques. In the largest of these studies enrolling 68 patients, Choi et al[33] found that C2 ganglion decompression led to therapeutic success, as defined by >50% reduction in patient-reported preoperative pain without analgesia use, in 70% of patients at 2.5-year follow-up. Four studies reported outcomes after cervical spinal nerve resection or ablation, the largest of which found that cervical dorsal rhizotomy provided full pain relief in 64% of patients, partial relief in 20%, and no relief in 16% at 5-year follow-up.[35]

DISCUSSION

Although surgical approaches to ON have been reported as early as the 1960s and anatomic and diagnostic studies related to ON pathophysiology have recently seen a resurgence in the Plastic Surgery literature, consensus has yet to be reached regarding the optimal approach to treating patients experiencing these headaches.[4,39–41] The purposes of this study were to define the current state of the evidence for surgical treatment of ON and to identify future opportunities for research related to ON management.

In 2005, Guyuron et al[42] published one of the first randomized, controlled trials on compression point release for migraine surgery: in 100 patients, randomized to surgical release versus nonoperative management for migraine headaches, surgical intervention resulted in significant symptom reduction in 92% of patients compared with 16% of control patients ($P < 0.001$). This study was soon followed by another RCT, this time comparing surgical decompression with sham surgery for migraine treatment in 75 patients and finding significant symptom reduction in 84% of surgery patients versus 58% of sham patients ($P < 0.05$).[43] More recently, Guyuron and Pourtaheri[44] have published on the use of fat grafting as a successful adjunct for surgically refractory

ROBINS-I tool for non-randomized studies	Risk of Bias Sources							
	Confounding	Participant Selection	Intervention Classification	Deviations from Intended Intervention	Missing Data	Outcomes Measurement	Selection of Reported Result	**Overall Risk of Bias**
Acar et al. (2008)	Moderate Risk	Low Risk	Low Risk	Low Risk	Low Risk	Serious Risk	Low Risk	**Serious Risk**
Afifi et al. (2019)	Moderate Risk	Low Risk	Low Risk	Low Risk	Critical Risk	Serious Risk	Low Risk	**Critical Risk**
Blake et al. (2019)	Critical Risk	Serious Risk	Low Risk	Low Risk	Critical Risk	Serious Risk	Low Risk	**Critical Risk**
Choi et al. (2015)	Moderate Risk	Low Risk	Low Risk	Low Risk	Low Risk	Serious Risk	Low Risk	**Serious Risk**
Ducic et al. (2014)	Moderate Risk	Low Risk	Low Risk	Low Risk	Low Risk	Serious Risk	Low Risk	**Serious Risk**
Finiels & Batifol (2016)	Critical Risk	Low Risk	Serious Risk	Serious Risk	Low Risk	Serious Risk	Moderate Risk	**Critical Risk**
Gande et al. (2016)	Moderate risk	Low Risk	Low Risk	Low Risk	Moderate Risk	Serious Risk	Low Risk	**Serious Risk**
Gille et al. (2004)	Moderate Risk	Low Risk	Low Risk	Low Risk	Low Risk	Serious Risk	Low Risk	**Serious Risk**
Hoffman et al. (2018)	Moderate Risk	Low Risk	Low Risk	Low Risk	Moderate Risk	Serious Risk	Low Risk	**Serious Risk**
Jose et al. (2018)	Moderate Risk	Low Risk	Low Risk	Low Risk	Low Risk	Serious Risk	Low Risk	**Serious Risk**
Kastler et al. (2018)	Moderate Risk	Moderate Risk	Low Risk	Low Risk	Moderate Risk	Serious Risk	Low Risk	**Serious Risk**
Keifer et al. (2017)	Serious Risk	Low Risk	Low Risk	Low Risk	Moderate Risk	Serious Risk	Low Risk	**Serious Risk**
Kim et al. (2015)	Moderate Risk	Low Risk	Low Risk	Low Risk	Serious Risk	Serious Risk	Low Risk	**Serious Risk**
Li et al. (2012)	Moderate Risk	Low Risk	Low Risk	Low Risk	Low Risk	Serious Risk	Serious Risk	**Serious Risk**
Lozano et al. (1998)	Serious Risk	Low Risk	Low Risk	Low Risk	Low Risk	Serious Risk	Moderate Risk	**Serious Risk**
Magown et al. (2009)	Serious Risk	Serious Risk	Low Risk	Serious Risk	Low Risk	Serious Risk	Low Risk	**Serious Risk**
Oh et al. (2004)	Critical Risk	Low Risk	Low Risk	Low Risk	Critical Risk	Serious Risk	Low Risk	**Critical Risk**
Pisapia et al. (2012)	Moderate Risk	Low Risk	Low Risk	Low Risk	Serious Risk	Serious Risk	Low Risk	**Serious Risk**
Slavin et al. (2006)	Serious Risk	Serious Risk	Low Risk	Low Risk	Serious Risk	Critical Risk	Low Risk	**Critical Risk**
Stechison et al. (1994)	Critical Risk	Serious Risk	Low Risk	Low Risk	Serious Risk	Serious Risk	Low Risk	**Critical Risk**
VanderHoek et al. (2013)	Critical Risk	Serious Risk	Low Risk	Low Risk	Critical Risk	Critical Risk	Low Risk	**Critical Risk**
Yeom et al. (2015)	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Serious Risk	Low Risk	**Serious Risk**

FIGURE 2. Risk of bias assessment using the ROBINS-I scale for nonrandomized studies. full color online

migraine headaches. Notably, the patients in question in all these studies had migraines, not ON, which is a distinct headache entity with different treatment responses.[2] In addition, the patients included in these studies had heterogeneous pain foci including frontal, temporal, and occipital pain. Nevertheless, these studies were foundational in establishing the plastic surgeon's role in treating refractory headache pain.

In 2009, Ducic et al[21] reported their results for 206 patients with neurologist-diagnosed ON who underwent GON and/or LON decompression with or without neurectomy. In this cohort, surgery resulted in an average pain reduction of 6 points on the VAS over at least 12 months of follow-up ($P < 0.0001$).[21] Several smaller retrospective cohorts have published similar results after decompression surgery, with symptom improvement rates between 81% and 96%.[9,19,45,46]

As the literature on ON decompression has grown, several anatomic and technical nuances have emerged. In reviewing their data on 229 patients undergoing occipital decompression for ON pain, Lee et al[45] found that removing the third occipital nerve, which is commonly encountered during the dissection for GON decompression, had no impact on symptom reduction or rate of neuroma formation. Moreover, for patients experiencing recurrent occipital pain after GON decompression, retrospective data from 71 patients by Ducic et al[22] found that GON neurectomy was associated with an average decrease in Migraine Headache Index Scores of 63% ($P < 0.001$).

Ultimately, only 22 articles met the inclusion criteria out of the more than 350 titles reviewed, all of which were found to have at least severe concern for bias. This finding highlights a substantial lack of high-level evidence on ON-specific management. Additional prospective cohort studies and randomized controlled trials assessing medical, office-based procedural, and operative treatment approaches for ON would be an important contribution to the literature on this condition. A specific research topic that may prove useful in guiding management includes the cost-effectiveness of attempting medical or office-based procedural interventions before progressing to operative intervention versus proceeding directly to operative intervention in select patients.

In conducting future research, it is critical to include rigorous guidelines for distinguishing between occipital *neuralgia* and occipital *migraine* or other headache disorders. Current studies use conflicting definitions of these disease states, which makes meaningful comparison between patient populations difficult. This discrepancy in part reflects an ongoing disagreement between surgeons currently offering surgery for a variety of headache disorders. Future studies focused on identifying specific predictors of a positive response to surgery with the goal of more precisely defining surgical candidacy would be helpful in this regard.

This study is limited by the low level of evidence and significant risk of bias of most of the articles meeting the inclusion criteria, which reduces its generalizability and highlights the need for additional high-level research on this topic. Those articles meeting the inclusion criteria used heterogeneous metrics for reporting their results, which in most instances impedes direct comparison.

CONCLUSIONS

A systematic review of high-level-of-evidence articles on ON treatment identified peripheral nerve decompression, ablation, and stimulation as useful therapeutic options for medically refractory occipital pain. Importantly, there is a paucity of high-level, low-bias evidence on this topic. These results highlight the importance of well-designed prospective, randomized studies to further elucidate the benefits of operative release that have been reported in case series. Moving forward, these studies, in addition to cost-effectiveness analysis and critical clarification of the specific disease processes being treated, will help advance the care of these challenging conditions.

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