
CLINICAL REPORT

Occipital Neuromodulation: Ultrasound Guidance for Peripheral Nerve Stimulator Implantation

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■ **Abstract:** We report a case of chronic left-sided occipital neuralgia in a 21-year old female patient. The patient in question suffered from chronic greater occipital neuralgia for a duration of many years, which had been refractory to other conservative medical management strategies. Blockade of the greater occipital nerve with local anesthetic was consistently useful in attenuating the patient's pain, though the effects were always short lived. Consequently, a successful trial of greater occipital nerve stimulation was undertaken.

Compared with spinal cord stimulation, peripheral nerve stimulation devices are often more difficult to precisely place given limited ability to visualize soft tissues with traditional fluoroscopic guidance. Additionally, there are anatomic subtleties relevant to the greater occipital nerve that potentially complicate stimulator lead placement, both from the standpoint of optimal neuromodulation efficacy and maximum safety. Ultrasound technology is a maturing imaging modality that allows soft tissue visualization and is consequently useful in addressing each of these aforemen-

tioned concerns. The specific use of high-frequency ultrasound guidance for this procedure simplified the initial device placement and allowed proper visualization of soft tissue structures, which facilitates precise device deployment. Additionally, the ability to identify relevant vascular structures may further increase the safety of stimulator lead placement. The potential advantages of ultrasound-augmented procedural techniques, specifically as they pertain to occipital stimulator lead placement, are discussed with particular emphasis on potentially decreasing intraoperative and postoperative complications while optimizing stimulation efficacy. ■

Key Words: occipital neuralgia, occipital nerve stimulation, neuromodulation, ultrasound guidance, peripheral nerve stimulation, neuropathic pain

INTRODUCTION

Chronic occipital pain, from a variety of causes, is a debilitating condition that poses significant challenges for patients. Symptomatology commonly manifests itself as pain that is lancinating in character, with paroxysmal exacerbations that are distributed from the internuchal line (between occipital protuberance and mastoid process) with radiations around the hemicranium up to the supraorbital ridge in some instances.¹⁻³ However, significant variability in clinical presentation

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Submitted: September 15, 2009; Revision accepted: February 13, 2010
DOI: 10.1111/j.1533-2500.2010.00381.x

does exist. The overall incidence of occipital neuralgia is unknown, though the available data suggests that it affects men and women with equal frequency.⁴ Some studies have indicated that up to 48% of patients previously diagnosed with migraine headache may, in fact, have symptoms chiefly attributable to irritation of the occipital nerve.⁴⁻⁶ Conservative medical management reported in the literature includes nonsteroidal anti-inflammatory drugs, opioids, nerve membrane stabilizers, transcutaneous electrical nerve stimulation, occipital nerve block (with local \pm steroid), Botox, and acupuncture. A significant number of patients, however, prove refractory to medical management and require more invasive therapeutic intervention.

Peripheral nerve stimulation, with percutaneous placement of electrodes, has been well described in case series as a promising therapy for occipital neuralgia refractory to more conservative therapies.⁷⁻⁹ Several mechanisms of action have been proposed, perhaps most interesting are the physiologic interconnections of occipital nerve afferents with the trigeminal nerve via the trigeminal nucleus caudalis.^{10,11} A more thorough discussion of mechanisms of action is, however, outside the scope of our intended discussion. While the precise therapeutic mechanism is yet to be determined, there is a growing body of literature supporting the clinical usefulness of occipital nerve stimulation (ONS) for refractory occipital neuralgia. Coupled with the debilitating nature of occipital neuralgia, ONS therapy is certainly a compelling emerging therapy.

Traditionally, percutaneous placement for peripheral nerve stimulating devices has followed techniques that rely upon external anatomic landmarks, clinical knowledge of normal anatomy, and supplementation (where possible) with fluoroscopy. The use of ultrasound guidance for the placement of ONS is a relatively novel approach to placement, which offers several advantages over the traditional techniques.¹² Namely, ultrasound visualization allows real-time imaging of both needle and the surrounding soft tissue structures during placement. This may enable the proceduralist to avoid unnecessary stimulation and/or trauma to arterial, muscular, and fascial structures, which often leads to increased patient morbidity and/or compromises the therapeutic success of the intervention.^{13,14}

CASE PRESENTATION

A 21-year old female suffering with chronic occipital headache pain for many years, presented to the pain clinic for further therapeutic options. Pertinent past

medical history included *Sydenham's chorea* (movement disorder involving bilateral upper extremity tremor), remote history of migraine headaches, and left-sided occipital headache of 5-year duration. Pain intensity was described as 7-9/10, and the frequency of symptoms was continuous without obvious precipitating, exacerbating, or attenuating factors. The patient had visited numerous academic medical centers, and received several exhaustive medical workups prior to her initial presentation at our institution. Although the patient's movement disorder had been satisfactorily treated with clonazepam, the left-sided occipital headaches proved refractory to conservative medical management. Various medical therapies that included diverse traditional pharmacotherapies, physical therapy and exercise, and instruction in several biobehavioral pain management strategies (biofeedback, relaxation, stress management), were unsuccessful in ameliorating the occipital neuralgia. In addition, the patient underwent thorough radiographic imaging which did identify a left-sided arachnoid cyst behind the central sulcus. This structural feature was thought not to be a contributing factor to the patient's pain complaints, and remained stable/unchanged with serial follow-up imaging throughout her treatment regimen. Despite the aforementioned interventions, only occipital nerve block (with local anesthetic and steroid) was helpful in providing significant relief on a consistent basis, although these beneficial effects were limited in duration.

Left-sided greater occipital nerve blockade, with 0.5% bupivacaine and 40 mg of triamcinolone, was consistently successful in reducing the patient's pain (near complete resolution). Initially, the duration of the effect of occipital nerve block was up to 8 months. With repeated blockade, however, the duration of the therapeutic effect became progressively shorter and eventually became much less effective over time. Ultimately, the patient was receiving only 1-2 weeks of relief from occipital nerve block. Pulsed radiofrequency of the greater occipital nerve was trialed upon one occasion without discernable benefit. After approximately 4 years of the aforementioned therapy, the patient sought medical advice regarding interventional therapies that may offer longer lasting relief. Based upon this desire, and the concern over sequelae associated with long-term steroid use, an interventional pain physician consulted with the patient. Occipital nerve stimulation trial was discussed as an option, and the patient was deemed to be an appropriate candidate (no contributing

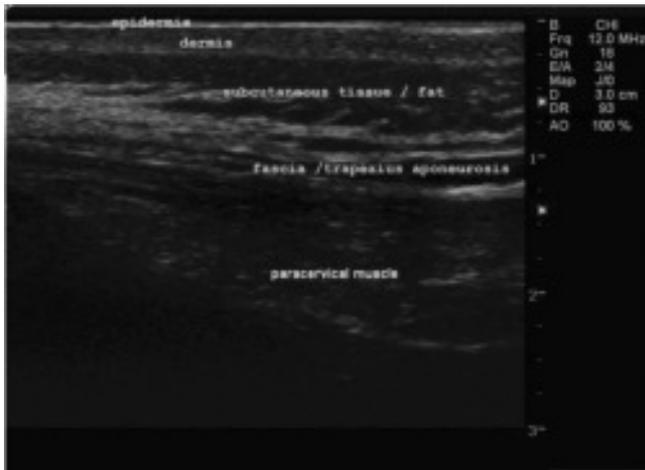


Figure 1. Ultrasound image of soft tissue structures during occipital nerve stimulator placement. Visualizing relevant tissues aid in assessment of appropriate depth of lead placement and avoidance of muscle stimulation. Note: The paracervical musculature represents the following at this cervical level: Semispinalis capitis, Rectus capitis, and Obliquus capitis in order of superficial to deep.

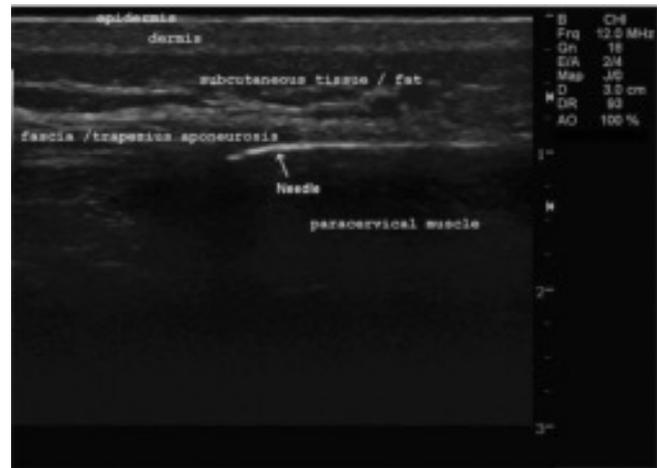


Figure 2. Ultrasound-assisted soft tissue visualization during occipital nerve stimulator needle placement. Note that deployed electrode is positioned at the level of trapezius aponeurosis and superficial to the paracervical musculature. Though not individually identified on the ultrasound image, the paracervical musculature represents the following at this cervical level: Semispinalis capitis, Rectus capitis, and Obliquus capitis in order of superficial to deep.

psychosocial issues, realistic expectations, sincere desire to fully participate in her therapy).

After informed consent the patient was taken to the operative suite and was placed in the prone position. Monitored anesthesia care was initiated without difficulty. Fluoroscopy was used to identify the C1 vertebral body, which was marked with a skin marker. The skin was then cleansed and draped in a sterile fashion. Lidocaine 1% with 0.5% bupivacaine mixed in a 1:1 ratio with 1:200,000 epinephrine were used to anesthetize the skin and subcutaneous tissues. A linear 12 MHz ultrasound probe (highest frequency available on the equipment used) in a sterile sheath was used to examine the occipital and suboccipital areas. Subcutaneous tissue and paracervical muscle layers were identified (Figure 1). A 14-gauge Tuohy style needle (Boston Scientific Neuromodulation, Valencia, CA, USA) was then advanced under ultrasound guidance ensuring adequate depth without intramuscular placement (Figure 2). Next, an 8-contact electrode was advanced to the end of the Tuohy needle, and the needle subsequently removed, leaving the stimulating lead placed deep to the subcutaneous tissue but superficial to the paracervical muscles. Fluoroscopy was used to confirm lead placement over the C1 vertebral body as previously described.^{5,8} (Figure 3) A pulse generator was then connected, and satisfactory impedance was confirmed. Appropriate paresthesia coverage was obtained in the suboccipital



Figure 3. Postprocedural confirmation of appropriate left-sided lead placement using traditional bony landmarks under fluoroscopy. Left-sided lead is positioned just cephalad to the superior margin of the C1 arch, approximately 2 cm inferior to the nuchal line.

and occipital area, in the normal anatomic distribution of the greater and lesser occipital nerves (ie, classical hemicranial pattern). Notably, this stimulation occurred without unintended muscle stimulation. The electrode

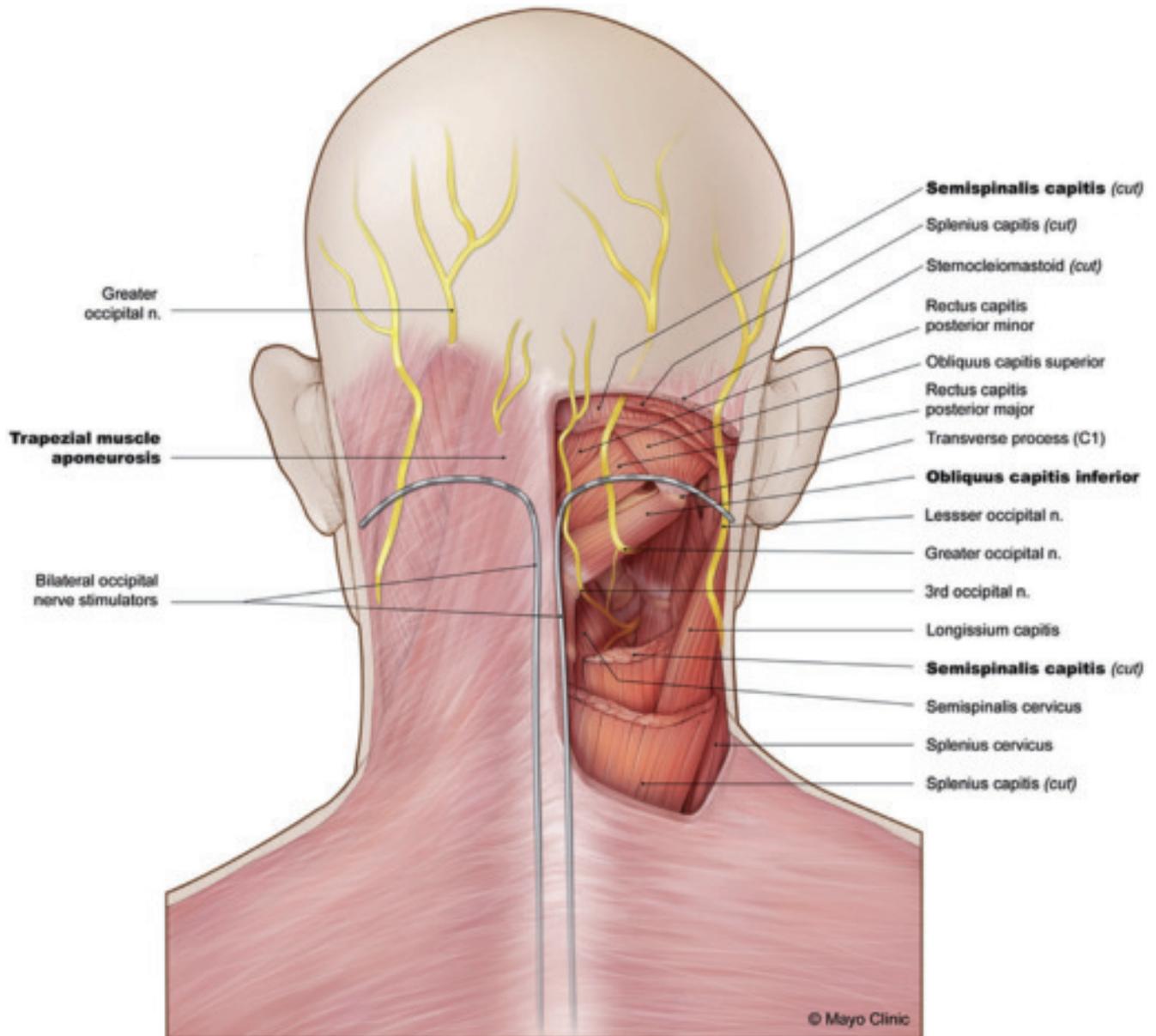


Figure 4. Occipitocervical anatomy, dissected views. The greater occipital nerve travels between the semispinalis capitis muscle and the obliquus capitis inferior, prior to penetrating the former and emerging through the trapezius muscle aponeurosis and/or semispinalis capitis fiber just inferior to the intermastoid line. Note that the pictured leads are for context only; final lead position is fully subcutaneous, overlying the trapezial aponeurosis, typically at the level of the C1–2 interface or overlying the C1 arch and oriented parallel to the intermastoid line.

was consequently anchored to the skin after which fluoroscopy was used to confirm good medial to lateral electrode orientation and to serve as a reference if the trial was deemed successful.

The patient experienced greater than 50% reduction in pain intensity immediately upon initiation of stimulation. The trial lasted 5 days, with the patient reporting a 60% reduction in pain intensity along with signifi-

cant improvement in quality of life indicators. At 5-day postimplant follow-up, the patient related a consistent pain intensity reduction of 60% along with significant improvement in her quality of life and ability to perform daily activities. Based upon this unmitigated successful reduction in symptoms, permanent occipital nerve stimulator implantation was scheduled and performed in a similar fashion. Post-implant follow-up at 5 months

continues to show consistent, significant relief of the patient's left-sided occipital neuralgia symptoms without any discernible device-related complications.

DISCUSSION

The greater occipital nerve (GON) is derived from contributions from the dorsal rami of the C2 and C3 spinal nerves. Its anatomic course ascends cephalad superficial to the obliquus capitis inferior and deep to the semispinalis capitis muscle.¹⁻³ After traversing the semispinalis capitis muscle and piercing the aponeurosis of the trapezius muscle (TMA), the GON travels parallel and slightly medial to the path of the occipital artery as it branches further to supply the occipital scalp integument (Figure 4).¹⁻³ Percutaneous surgical approaches for stimulation have typically relied upon external anatomic landmarks such as the occipital protuberance and the mastoid process to approximate the lie of the GON in relation to occipital artery pulsation. Based upon these external landmarks, stimulating electrodes are placed superficially in the subcutaneous plane and oriented perpendicular to the course of the nerve. Supplemental fluoroscopic visualization (PA orientation) confirms the transverse path of the needle/electrode lead relative to the underlying calvarium and C1 vertebra.^{5,11,14} Limitations of this approach include an inability to see soft tissue anatomy (such as nerve, artery, muscle, and fascia), which makes precise placement (especially in regards to appropriate depth) more challenging.

As demonstrated with the included ultrasound images, we were clearly able to identify the soft tissue structures of the sub-occipital regions. Subsequently, we were able to precisely place the needle in the connective tissue plane between the underlying paravertebral muscle and overlying subcutaneous fat, oriented just cephalad of the superior margin of the C1 arch and approximately 2 cm inferior to the nuchal line (Figure 5). The procedural needle tip can be clearly visualized at it traverses the subcutaneous plane immediately superficial to the trapezius muscle aponeurosis (TMA) and semispinalis capitis fibers. This enabled us to avoid traumatizing paravertebral muscle, which may have complicated the trial in terms of decrease efficacy and increased morbidity. Traditional non-guided approaches to ONS are suboptimal since they may lead to painful muscle stimulation and inefficient electrical coverage if the depth of lead implantation is inadequate. Additionally, we hypothesize that the incidence of lead tip erosion, which is partially related to depth of lead placement, will likewise decrease with ultrasonic confirmation of specific tissue planes.¹⁵ The precise depth of implantation is immediately confirmed with ultrasonography, which may enable better optimization of stimulation parameters during programming.

Ultrasound visualization allows real-time imaging of both needle and soft-tissue during placement and enables the proceduralist to avoid unnecessary stimulation and/or trauma to adjacent muscular and fascial

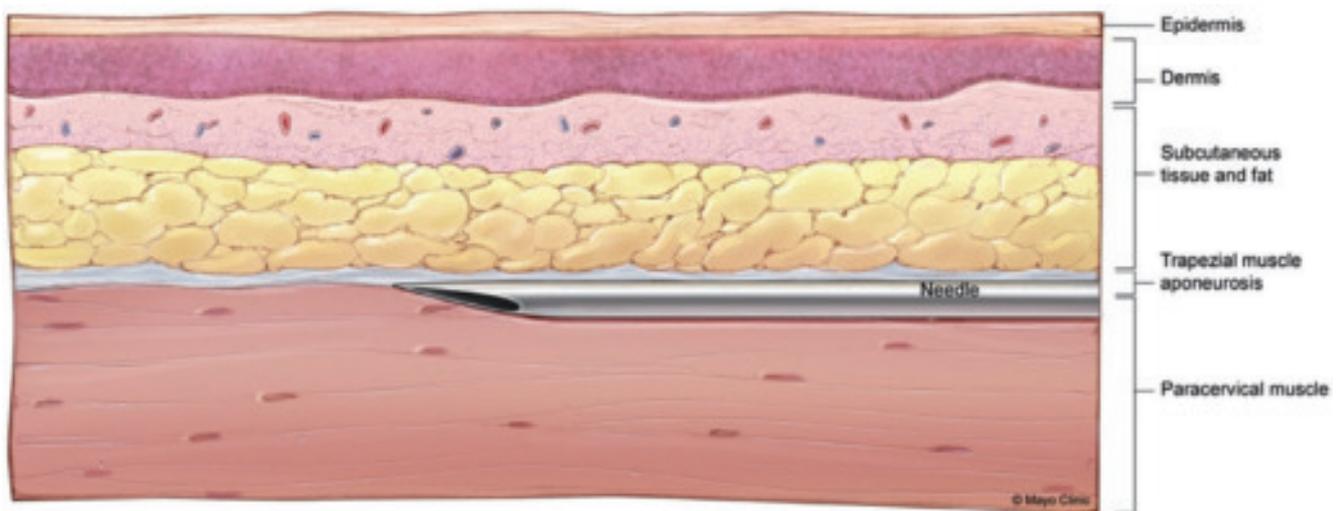


Figure 5. Occipitocervical axial view schematic. Schematic axial representation of the relevant soft tissue structures which are reliably seen with ultrasound-guided placement of an occipital nerve stimulator lead. Note that final needle placement is superficial to or in the trapezius aponeurosis, thus, avoiding trauma to the underlying muscle.

structures. Limiting the invasiveness and potential unintended damage to surrounding structures are worthy goals for any interventional procedure. Additionally, unnecessary trauma to the muscle may lead to failed or equivocal results of occipital nerve stimulation trials. Reported cases of lead tip erosion can also likely be attenuated by intra-operative ultrasound utilization. The wide availability and relative low-cost of ultrasound technology should reduce barriers to its use in assisting with placement of occipital stimulator devices. Along with a comprehensive understanding of relevant anatomy, real-time ultrasound guidance for precise stimulation lead placement may offer significant advantages for both treatment efficacy and safety. Further study is necessary to corroborate these assertions, and to further identify areas for procedural enhancement.

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