Chapter 19

Peripheral Extracranial Neurostimulation for the treatment of Primary Headache and Migraine:

Introduction

1) The occipital nerve is involved in pain syndromes originating from nerve trauma, myofascial spasm around the nerve fibers, cervicogenic disease, posterior fossa surgery, and transformed migraine. Inflammation of the C2 nerve root will also cause severe symptoms in this region, consistent with cervical radiculitis. The transformed migraine begins with pain in the occipital nerve distribution and then evolves into a full migraine headache. Neurostimulation has also been employed in the treatment of chronic tension-type headache, hemicrania continua, short lasting unilateral neuralgiform headaches, and cluster headaches. Treatment of these headache conditions may include direct stimulation of the greater and lesser occipital, supraorbital and supratrochlear, auriculotemporal, and infraorbital nerves. More recently, 360° cranial stimulation has been described as well.

The treatments of headache pain syndromes include oral medications, physical therapy, nerve blocks, and radiofrequency ablation. In the past, occipital neurectomy, which involved the destruction of the nerve, was performed by Neurosurgery, but this fell out of favor because of deafferentation syndrome and the overall long-term worsening of the pain syndrome. Cryotherapy and pulsed radiofrequency appear to have some efficacy, but unfortunately are short lived in duration, and require the patient to undergo multiple procedures over time. Surgical decompression of the occipital nerves has also been described. Stimulation of the nerves has evolved over the past decade and has become a standard treatment of chronic headache pain that does not respond to conservative measures.

Technical Overview
Prior to considering the technical aspects of implantation of extracranial leads, the clinician must confirm the diagnosis of corresponding neuralgia. The clinician should have a clear mental picture of the neuroanatomy including the branches of the respective nerves. The diagnostic workup for peripheral cranial neuralgia includes a history of pain originating or ending in the nerve area; a physical examination that includes tenderness over the respective nerve and nerve root distribution, and a temporary response to injection of local anesthetic that provides relief for the duration of the medication used.

Once the patient is felt to be an appropriate candidate for stimulation, the anatomy is reexamined and the skin is evaluated for lesions, texture, and bony prominences. The peripheral nerves branch into multiple fibers and the leads must cover a wide area to obtain appropriate stimulation. The respective cranial region is shaved to remove hair, which can be a nidus for infection. The trial leads are often placed via a single needle stick on the affected side(s), and the permanent leads are most commonly placed via a midline incision for occipital neural stimulation, parietal/temporal incision for a auriculotemporal nerve stimulation, and incision just behind the hairline for supraorbital/supratrochlear stimulation. Infraorbital stimulation requires needle entry over the maxillary region.

By using a widely spaced octipolar lead array, the area of stimulation increases covering the multiple branches of the nerve. With temporary leads, once the implant is placed by fluoroscopy, the leads are secured to the skin by a suture or tape. In permanent occipital nerve implants, the surgical process begins by making an incision at the midline just below or above the occipital prominence. Tissue separation can be achieved with the blunt use of a surgical scissor to minimize trauma. Once the fascia is visualized, a cautery tool is used to achieve hemostasis. Once hemostasis is acceptable, a needle is placed in the desired path of the planned lead placement. Local anesthetic should be placed only at the needle entry location. If local anesthetic is placed in the path of the needle, it will be difficult to confirm stimulation on the operating room table. Use of epinephrine in local anesthetic may reduce bleeding. Fluoroscopy is important to guide and confirm the needle path. In many cases, the needle must be slightly bent to achieve the desired depth and course of the lead implant. Needles with a plastic stylet are often easier to use since the metal stylet may be difficult to remove once the needle is bent. The depth of the needle should be just below the dermis in the subcutaneous tissue. Once the stylet is removed, the lead is placed to the tip of the needle using fluoroscopy to confirm placement. The needle is then pulled distally while the lead is held in position using X-ray confirmation, while the tissue is stabilized by holding pressure above the lead.
Once the lead is in the desired location, a handheld programmer is used to activate the leads and to achieve stimulation. In many cases, an array with multiple cathodes is successful, which will help spread the current.

For permanent implants, when the patient's stimulation is acceptable, the leads are anchored to the fascia with nonabsorbable suture. At each incisional site, a coil is then made as a form of strain relief and the leads are tunneled to the pocket. Pocketing options include the anterior chest wall in the subclavicular region, posterior axillary region, buttock, and flank. If pockets are made in more distal locations, it may be necessary to add lead extensions to reach the pocket. Figures 19.5-19.8 demonstrate lead and generator placement techniques.

**Method for occipital stimulation:**
The targets for the leads vary based on physician preference and can range from a lateral C1 approach to a perpendicular greater occipital nerve approach. The most common area for placement for the leads is at an angle from the midline to the lateral edge of the occipital bone, in order to capture fibers of both the greater and lesser occipital nerves (Figures 19.1-19.4). This placement allows for proper stimulation even in the event of mild-to-moderate migration.

**Method for supraorbital/supratrochlear stimulation:**
Insertion site for the lead is just posterior to the anterior hairline of the temporal region advancing a bent/curved needle with plastic stylet over the supraorbital margin placing electrode contacts adjacent to supraorbital and supratrochlear nerves. Care must be taken not to perforate the skin, and keep the needle in the proper trajectory avoiding inferior placement of lead over orbit.

**Method for auriculotemporal stimulation:**
Insertional lead is performed posterior and superior to the ear advancing the lead anteriorly over the auriculotemporal nerve.

**Method for infraorbital stimulation:**
Insertion of lead is performed using a bent/curved needle with plastic stylet from the maxillary region immediately inferior to the orbit was
electrode contacts overlying the nerve. If a wide spaced eight contact lead array is used, simultaneous stimulation of infratrochlear, infraorbital, zygomaticofacial, lacrimal and infraocular nerves may be achieved for treatment of cluster headache.

**Method for Halo 360° cranial stimulation:**

The targets for the leads using this technique include bilateral stimulation of supraorbital, supratrochlear, zygomaticotemporal, auriculotemporal, greater occipital, and lesser occipital nerves. There is also stimulation noted of the terminal branches of bilateral zygomaticofacial, greater auricular, third occipital nerves and C2/C3 nerve roots. This method requires use of a 32 contact internal pulse generator system and four leads each with eight electrode contacts, with wide 6 mm spacing between the adjacent electrode contacts. Bilateral leads are placed superior to the ear advancing a needle with bent/curved stylet anteriorly with the electrode contacts overlying bilateral supraorbital, supratrochlear, zygomaticotemporal and auriculotemporal nerves. Bilateral leads are simultaneously placed posteriorly overlying greater/lesser occipital, greater auricular, and branches of the third occipital nerves, as well as ascending branches of the posterior rami of C2 and C3 nerve roots.

**Risk Assessment**

1. The depth of the leads and generator should be carefully considered. The ideal lead placement is in the tissue just below the dermis. If the lead is over a pressure point, the depth should be slightly increased. The generator depth should be 1.5-3.0 cm.

2. The tissue of the planned surgery should be evaluated for lesions or infection. If an area of irritation exists, surgery should be delayed.

3. The lead may be prone to erosion through the skin. Diabetics and those with a history of skin disorders should be approached carefully.

4. The patient's postoperative movement is a fine balance. If you allow the patient to have unrestricted movement, it may cause lead
migration, but if too restricted fibrosis can occur which may cause restricted movement of the neck and pain with palpation, over the wiring.

5. Injection and surgical manipulation of the occipital or temporal region could lead to extensive bleeding of the occipital or temporal arteries respectively, or to arterial clotting. Either process could lead to tissue sloughing or a need to reoperate on the patient.

6. Proper surgical planning would include assessment of patient positioning surgical planning for tunneling since a stab incision may need to be made between the internal pulse generator and the cranial leads in order to tunnel the leads from skull to IPG pocket.

Risk Avoidance

1. Prior to surgery, the physician should review the patient's tissue for infection or lesions in the surgical area. The surgery should be delayed if there is any doubt about the safety of moving forward.

2. Prior to surgery, the physician should review the patient's medications and assure that all medical conditions are under adequate control prior to moving forward. Drugs that affect bleeding should be discussed with the proper medical specialist and discontinued when safe and advisable.

3. Preoperative and intraoperative antibiotics are recommended. It is advisable to vigorously irrigate the wound prior to closure.

4. Prepping and draping of the occipital region can be difficult because of the need to operate in the region of the patients head where there is also a need for airway access. This issue is very important when tunneling the leads. In positioning the patient, the pocket location is important. The options for pocketing can be the chest wall, which requires a lateral decubitus position, or the back or buttock which can be done in the prone position.
5. It is critical to adequately measure the lead length and try to match it to the insertion and pocket location. There should be adequate length to allow for a stress relief loop at both the lead anchoring site and the generator location. This will reduce both the risk of migration and fibrosis.

6. The tissue in the area of the occipital and temporal regions should be handled gently. It is important to separate the tissue with care and to minimize bleeding. The tissue should close evenly and without stress to maximize tissue circulation.

7. Postimplant, the patient's movement should be restricted for the first 6 weeks. At the end of 6 weeks, the patient may benefit from musculoskeletal treatment by a certified physical therapist.

**Conclusions**
Peripheral cranial stimulation is becoming a common procedure to treat chronic headaches. It is an alternative to more destructive procedures, and to high-dose oral medications that may cause systemic side effects and complications as well as rebound headaches, and addictive disorders. Peripheral extracranial nerve stimulation are valuable low-risk procedures that will continue to improve as lead technology and programming is enhanced by future research and development.