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Temporary Occipital Nerve Peripheral Nerve Stimulation at C2 in Refractory Occipital Pain: Case Series

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Background: Occipital pain is a debilitating condition often resistant to conventional therapies. Peripheral nerve stimulation (PNS) that targets the occipital nerve at the C2 level has emerged as a novel neuromodulation strategy offering targeted relief.

Case Report: This retrospective case series included 4 patients with refractory occipital pain, cervicogenic headaches, and occipital neuralgia treated with temporary percutaneous implantation of the SPRINT® PNS System (SPR Therapeutics) at C2. Patients underwent 8-week trials followed by longitudinal follow-up periods up to 24 months later. Improvements were noted in pain reduction, physical function, and sleep quality, with decreased or discontinued opioid use and high satisfaction scores. No procedural complications occurred.

Conclusions: Temporary occipital nerve PNS at C2 may serve as an effective and safe short-term therapeutic option for refractory occipital pain, though the topic warrants further prospective studies.

Key words: Occipital nerve, occipital pain, peripheral nerve stimulation, neurostimulator implant

BACKGROUND

Chronic headaches are the second most prevalent disease (1) and the second most common cause of disability worldwide (2). Meanwhile, occipital pain is a debilitating condition that can be difficult to manage. Occipital headaches can present different symptomatology depending upon their etiology. These causes include occipital neuralgia, cervicogenic headache, and occipital migraine (3).

Individuals experiencing occipital pain that resists standard therapies may be considered for peripheral nerve stimulation (PNS). PNS of the occipital nerve delivers electrical stimulation via subcutaneous electrodes, targeting the neuropathic component of pain (3). Occipital nerve stimulation is one of the emerging neuromodulation techniques for treating occipital headaches.

We previously reported a novel approach for PNS implantation at the C2 location using a permanent PNS system (4). In this article, we present a case series demonstrating the technique for using a temporary peripheral stimulator system at the C2 location, as well as evaluating the effectiveness of PNS in managing occipital headaches.

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CASE REPORT

In this case series, we retrospectively reviewed patients who received percutaneous implantation of neurostimulator electrodes with the SPRINT® PNS System (SPR Therapeutics) from August 2022 to December 2023. To be considered for inclusion, patients must have received PNS for a duration of 8 weeks between August 2022 and December 2023. Data were collected from patients' electronic medical records, including demographics, associated diagnoses, previous treatment modalities, pre-procedural and post-procedural opioid use, pain scores before and after the procedure, and pain management regimens. After enrollment, patients were contacted for their follow-up surveys in June 2024.

Approval of this case series was given by our institutional review board (IRB). The need for consent was exempted in accordance with the IRB. We used the CARE checklist when writing our report (5).

Procedure

Each patient was placed in a prone position. The ultrasound machine used was an OEC® 9900 Elite, ES-064 (General Electric HealthCare). The C2 level was identified using high-frequency linear ultrasound by the bifid spinous process, and the probe was rotated so that the lateral edge moved cranially to the transverse process of C1. The inferior obliquus capitis muscle, semispinalis capitis muscle, occipital nerve, C2 dorsal root ganglion, and vertebral artery were identified. Using fluoroscopy in an anteroposterior view, a 20-gauge blunt introducer was advanced from the lateral shadow of the T1-T2 transverse process rib junction, from the caudal to the cranial direction. The tip was tracked with ultrasound out of plane until it became located between the obliquus capitis inferior and semispinalis capitis muscles, lateral to the greater occipital nerve. This orientation brought the lead parallel to the length of the greater occipital nerve and medial to the lesser occipital nerve. The placement was confirmed with an x-ray, and the patient felt a comfortable vibrating sensation in the distribution of the greater occipital nerve. Then the stimulating needle stylet was removed, and the preloaded lead was placed down the stimulating needle cannula and then deployed by applying pressure over the nerve location and needle tip. The proper placement location was confirmed with fluoroscopy in an anteroposterior view, and it was confirmed under ultrasound that the lead was lateral to the nerve. Eight weeks after the PNS implant, the leads were removed, completely intact.

Figs. 1 and 2 show the fluoroscopic and ultrasound images taken during the procedure.

RESULTS

This case series comprised 4 patients (2 women, 2 men; age range 51-70 years; BMI 26.96-41.88) who underwent 8-week trials of greater occipital nerve PNS (2 bilateral, 2 unilateral) for occipital pain, occipital headaches, and cervicogenic headaches. Follow-up surveys were administered at 8, 13, 16, and 24 months after the explantation of the PNS device. The varying follow-up intervals reflect differences in implantation timing, though all surveys were conducted on the same date. Assessment instruments included the Patient Global Impression of Change (PGIC) scale, Patient-Reported Outcomes Measurement Information System® (PROMIS®) v2.0 - Neuropathic Pain Quality 5a, PROMIS® v1.0 - Sleep Disturbance 6a, PROMIS® v2.0 - Physical Function 6b, and a custom PNS questionnaire. Raw scores on the PROMIS® scales were converted to standardized T-scores (mean = 50 and SD = 10, based on the general population of the U.S.), with higher scores indicating greater symptom burden. The patient breakdown is as follows.

Patient #1: A 61-year-old woman with occipital pain and post-laminectomy syndrome received bilateral PNS. She demonstrated limited cervical range of motion and severe occipital tenderness. Following 8 weeks of limited stimulation use, she reported very good improvement on the left side and mild improvement on the right. During the follow-up at 24 months after the explantation, her PROMIS® T-scores were 19 (sleep disturbance), 12 (physical function), and 8 (neuropathic pain quality). Patient satisfaction was 21-30%. No opioid use was reported before or after the procedure.

Patient #2: A 70-year-old man with bilateral occipital neuralgia and cervical spondylosis, status post-C3-C7 laminoplasty, received bilateral PNS. Presenting symptoms included intermittent sharp sensations similar to electric shocks in the left neck and periauricular region, radiating to the forehead. The patient's other symptoms were bilateral superior neck pain and occasional unilateral ocular redness. Following 8 weeks of stimulation, he reported 30-50% pain reduction. Opioid requirements decreased from 40 mg of oxycodone to 5-325 mg of oxycodone-acetaminophen every 12 hours. At the sixteenth-month follow-up, the patient's PROMIS® T-scores were 14 (sleep disturbance), 20 (physical function), and 14 (neuropathic pain quality). Patient satisfaction was 41-50%.

Patient #3: A 51-year-old woman with occipital pain, cervicogenic headache, and cervical spondylosis received unilateral right-sided PNS. Her history included failed occipital nerve blocks, medial branch blocks at C2-C4, and radiofrequency ablation with transient relief followed by neuritis. After the PNS procedure, her pain severity decreased from 8/10 to 2/10, with excellent treatment response. At the thirteenth-month follow-up, the patient's PROMIS® T-scores were 9 (sleep disturbance), 29 (physical function), and 10 (neuropathic pain quality). Patient satisfaction was 51-60%. No opioid use was reported.

Patient #4: A 65-year-old man with post-motor vehicle accident whiplash injury and persistent right upper cervical axial pain received unilateral right-sided PNS. Despite prior conservative management, radiofrequency ablation of the right greater occipital nerve, and a C7-T1 cervical epidural steroid injection, he experienced persistent debilitating pain, which was exacerbated by neck movement. After receiving PNS, he achieved near-complete symptom resolution, with full cervical range of motion. A daily regimen of 60 mg of duloxetine was discontinued after the implantation. At the eighth-month follow-up, the patient's PROMIS® T-scores were 8 (sleep disturbance), 27 (physical function), and 5 (neuropathic pain quality). Patient satisfaction was 81-90%. No opioid use was reported.

Patient demographics, clinical characteristics, and outcomes are summarized in Table 1 and Figs. 1-4.

DISCUSSION

This case series presents 4 patients who received percutaneous PNS placement to manage refractory occipital pain. We evaluated the efficacy of PNS by observing the changes in analgesic use along with surveys measuring patients' pain scores, quality of sleep, and physical function. Our findings demonstrate that 3 patients experienced pain relief after receiving the implants, indicating that those implants decreased the patients' pain. However, one patient reported the same pain before and after using the device. These findings highlight the need for future research on the potential of PNS as an option for treating chronic occipital pain.

Pain and quality of life measures are subjective for every individual, which can create potential bias in pain and PROMIS® survey scores. For example, pain scores may be skewed because of patients' coexisting conditions or pain in other areas of the body. Similarly, coexisting painful conditions can also influence the results of the physical function surveys. To reduce this bias, we emphasize analgesic use as the secondary outcome measure, since decreases in opioid use after PNS implantation can be a more objective indicator of

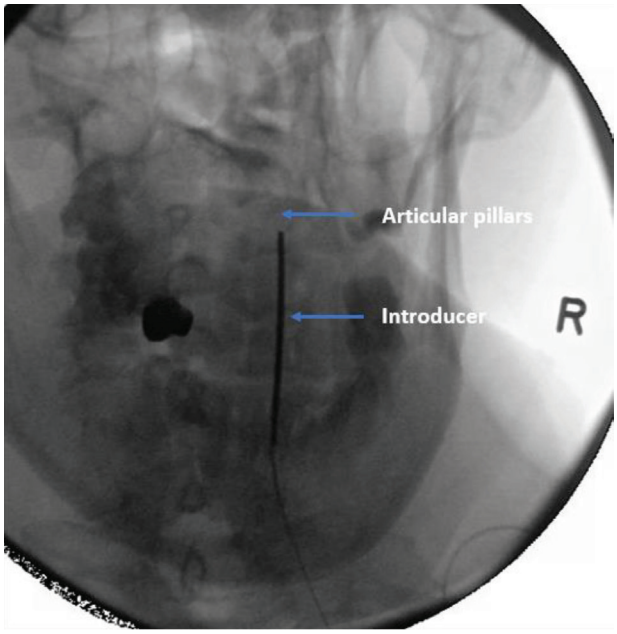

Fig. 1. Fluoroscopic image showing the introducer needle reaching the articular pillars at the lateral aspect of the greater occipital nerve region.

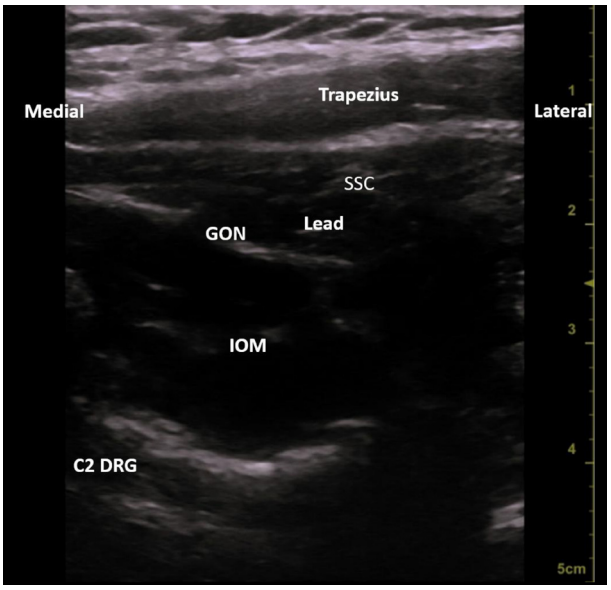

Fig. 2. Intra-procedural ultrasound.
SSC = semispinalis capitis; GON = greater occipital nerve; IOM = inferior obliquus capitis muscle; DRG = dorsal root ganglion

Table 1. Clinical characteristics and outcomes of patients receiving PNS implants.

Patient	Age	Location of Implant	Associated Diagnoses	Pre-Procedural Opioid Use	Post-Procedural Opioid Use	Complications
1	61	Bilateral	Post-laminectomy syndrome (cervical); occipital pain; fibromyalgia	None	None	None
2	70	Bilateral	Bilateral occipital neuralgia; cervical spondylosis without myelopathy; entrapment neuropathy	Oxycodone HCl 40 mg, oxycodone-acetaminophen 5-325 mg tabs, 10-325 mg tabs	Oxycodone-acetaminophen 5-325 mg (one tablet oral every 12 hours PRN)	None
3	51	Right	Occipital pain; cervicogenic headache; cervical spondylosis without myelopathy	None	None	None
4	65	Right	Occipital pain	None	None	None

Table 2. Changes in opioid use after the procedure, showing a decrease in overall opioid use.

Pt #	Pre-Procedural Opioid Use	Post-Procedural Opioid Use	Changes in Opioid Use at Explantation
1	No	No	None
2	Oxycodone HCl 40 mg Oxycodone-acetaminophen 5-325 mg tabs	Oxycodone-acetaminophen 5-325 mg	Stopped oxycodone HCl 40 mg
3	No	No	None
4	No	No	None

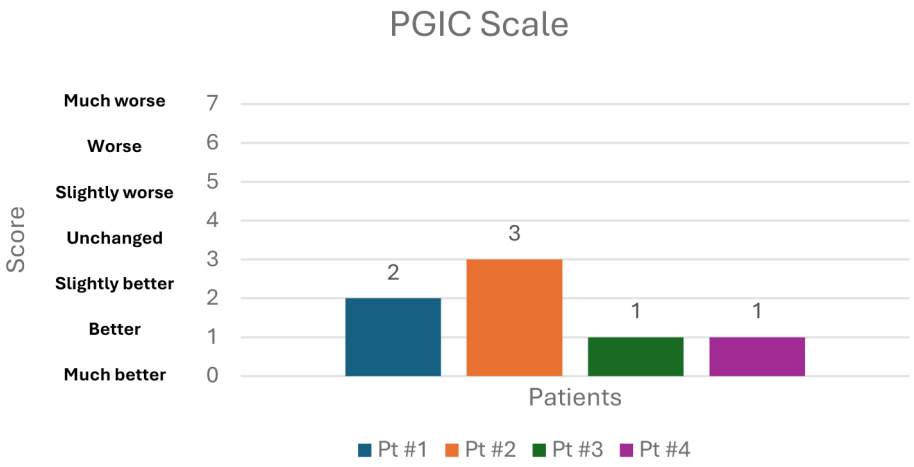

Fig. 3. Patient Global Impression scale findings at follow-up visits.

the therapy's effectiveness. Only one of our patients was using opioids, which he stopped taking after receiving PNS. Our findings demonstrate how the incorporation of PNS into pain management strategies can alleviate the opioid burden on health care systems and reduce overall opioid consumption. This approach allows us to avoid committing to a permanent implant, minimizing the risks associated with long-term implantation and enhancing patient comfort.

The occipital nerves are a group of nerves originating from the cervical spinal nerves C2 and C3. There are 3 primary occipital nerves: the greater occipital nerve, the lesser occipital nerve, and the third occipital nerve. The greater occipital nerve is the largest of the 3 and arises from the medial division of the dorsal ramus of the C2 spinal nerve. The former nerve travels between the obliquus capitis inferior and semispinalis capitis muscles and then pierces the semispinalis capitis muscle and runs alongside the occipital artery. The greater occipital nerve provides sensory innervation to the skin of the posterior scalp up to the coronal suture (6).

The nerve location between the muscles at C2 is more consistent than the commonly used peripheral stimulator implant in the occipital area. Because the nerve terminal branches are subcutaneous and exhibit greater anatomical variability, the chances of failure increase. Furthermore, due to the superficial position of these branches, there is a higher risk of infection and

lead erosion in the occipital region than in the deeper, more consistent location at the C2 approach.

Neuromodulation of the occipital nerve has been studied through Raoul et al's (3) performance of transcutaneous electrical nerve stimulation (TENS) and through Strand et al's (7) implantation of PNS devices. One review article by Staudt et al (8) concludes that PNS is an effective procedure in patients with occipital neuralgia.

The high level of evidence for occipital nerve stimulation by the percutaneous temporary SPRINT® PNS System is provided in a recently published multicenter prospective study by Gutierrez et al, in which 90% of the patients achieved clinically significant (≥ 30%) reductions in average occipital pain and/or pain interference after 2 months of treatment. Additionally, 85% of the patients experienced ≥ 50% pain reductions, with responders reporting mean reductions of 64% in pain and 75% in pain interference. Notably, 60% of the patients experienced a ≥ 50% reduction in pain intensity, while 75% experienced a ≥ 50% reduction in pain interference (9).

We employed a novel technique in which the lead was advanced from the junction of the T1-T2 transverse processes and ribs, directing it from the caudal to the cranial position. The final placement of the lead was positioned between the obliquus capitis inferior and the semispinalis capitis muscles. The lead exit positioning was in the upper thoracic region; this secure placement enhanced patient acceptance and optimized the logistical considerations for the change of dressing. Unlike permanent PNS implants, which have higher rates of lead migration, lead fracture, concern for incision location in the neck, and infection, our temporary SPRINT® PNS System has not demonstrated any of these complications in our patients (10). Combining x-ray and ultrasound guidance enhances the accuracy of lead placement near the occipital nerve while reducing x-ray exposure. We considered using a percutaneous temporary SPRINT® PNS System due to its less invasive nature and potentially lower risk of complications than the permanent implantation of a PNS device may pose (10,11).

Our case series presents insights into the use of percutaneous PNS for refractory occipital pain, and we aim to contribute to the growing body of evidence supporting the use of PNS as a valuable treatment option for patients suffering from these complex pain conditions. However, there are limitations to consider. The small sample size

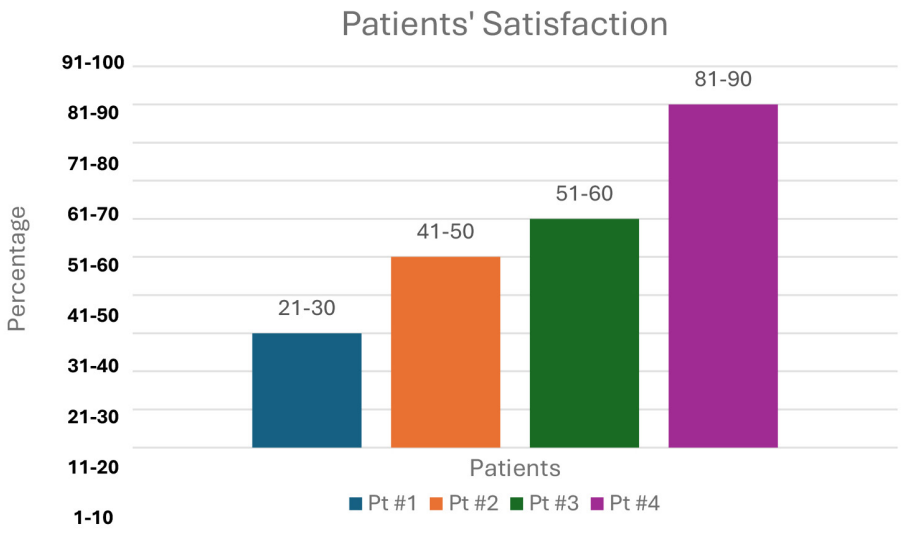

Fig. 4. Patients' satisfaction rating at the time of follow-up surveys (Patient 4 at 8 months, Patient 3 at 13 months, Patient 2 at 16 months, and Patient One at 24 months).

Table 3. Comparisons between overall pain management at the time of presentation for procedure and the pain management prescribed at the time that the PNS system was removed.

Pt #	Pain Management at the Time of Procedure	Pain Management at the Removal of the PNS System
1	None	None
2	Oxycodone HCl 40 mg, oxycodone-acetaminophen 5-325 mg tabs, topiramate 100 mg oral 2 times daily	Oxycodone-acetaminophen 5-325 mg (one tablet oral every 12 hours PRN), topiramate 100 mg (oral 2 times daily)
3	None	None
4	duloxetine HCl 30 mg, one capsule daily for one week, 60 mg	None

of 5 patients may limit the applicability of this case series to the general population. Additionally, retrospective data collection can introduce biases in patient-reported outcomes and pain scores, especially since they can be subjective to the individual. We recommend that future researchers perform larger, prospective trials with more standardized objective outcome measures.

CONCLUSIONS

This case series demonstrates that temporary PNS at C2 for the greater occipital nerve is a short-term therapeutic option for treating refractory occipital pain.

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