PAIN MEDICINE CASE REPORTS

ISSN 2768-5152

Volume 9, Number 1, pp. 27-31

Externally Powered Peripheral Nerve Stimulation With a Separate Receiver at the Brachial Plexus Nerve for the Treatment of Pain due to Metastatic Invasion From Advanced Breast Cancer: A Case Report

Alvise Martini, MD, Vittorio Schweiger, MD, Libera Villagrossi, MD, Alex Patton, MD, Giuseppina Poni, MD, and Enrico Polati, MD

Background: Cancer pain, particularly neuropathic pain, remains a significant clinical challenge, often refractory to conventional analgesic therapies.

Case Report: This case study aims to assess the efficacy of the Freedom® peripheral nerve stimulation (PNS) System in managing chronic intractable cancer-related neuropathic pain. This particular case was managed at a specialized pain management center with access to advanced neuromodulation technologies. A 41-year-old woman with ductal mammary carcinoma and pectoral metastasis experienced severe pain in the right arm unresponsive to conventional treatments. A Freedom PNS System was implanted at the brachial plexus using a permanent surgical technique.

Following the implantation of the Freedom PNS System, the patient's pain score decreased from 9/10 to 2/10, the Oswestry Disability Index improved from 66% to 12%, and Euro Quality of Life 5-Dimension 5-Level Version utility indexes increased significantly.

Conclusions: This case study demonstrates that the Freedom externally powered PNS System can be an effective and safe treatment for chronic cancer pain.

Key words: Peripheral nerve stimulation, cancer pain, brachial plexus

BACKGROUND

Cancer-related pain, particularly neuropathic pain, remains a significant clinical challenge, often inadequately managed by conventional analgesic therapies. Neuropathic pain arises from damage or dysfunction of the nervous system and is characterized by symptoms, such as sharp, burning, or shooting pain, which can severely impair a patient's quality of life (QoL). The limitations of traditional pharmacologic treatments, including opioids and adjuvant medications like gabapentinoids, are well documented. These limitations include not only insufficient pain relief, but also substantial adverse effects that can further diminish patients' QoL (1).

Brachial plexopathy is a rare, but severe complication that may affect patients suffering from advanced breast cancer (2). Together with functional limitations

From: Department of Anesthesia, Intensive Care and Pain Therapy, Verona University Hospital, Verona, Italy

Corresponding Author: Alvise Martini, MD, E-mail: alvise.martini@univr.it
Disclaimer: There was no external funding in the preparation of this manuscript.
Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.
Patient consent for publication: Consent obtained directly from patient(s).
This case report adheres to CARE Guidelines and the CARE Checklist has been provided to the journal editor.
Accepted: 2024-08-08, Published: 2025-02-28

and vascular disturbances (e.g., weakness, limitation of shoulder range of motion, malignant lymphedema, sensory alterations), one of the most reported disabling symptoms is the severe neuropathic pain due to brachial plexus compression and/or invasion.

The quest for more effective pain management strategies has led to exploring neuromodulation techniques, including peripheral nerve stimulation (PNS). To date, the use of neurostimulation in brachial plexopathy due to breast cancer is only anecdotal (3). We report a case of an advanced breast cancer patient with neuropathic pain from brachial plexus invasion, refractory to conventional pharmacological treatments, whom we treated with a novel, less-invasive peripheral brachial plexus stimulation modality using a totally implanted wireless stimulation catheter.

The Freedom® PNS System, manufactured by Curonix LLC, (Pompano Beach, FL) represents an innovative approach within this domain. This system uses high-frequency electromagnetic coupling (HF-EMC) technology to power an implanted neurostimulator, offering the potential for effective and sustained pain relief with a minimally invasive procedure (4).

This case report details the application of the Freedom PNS System in a patient with intractable cancer-related neuropathic pain, highlighting the procedural technique, postoperative outcomes, and overall impact on the patient's QoL. It aims to contribute to the growing body of evidence supporting the use of PNS in managing severe cancer-related neuropathic pain and to underscore the potential benefits and considerations of this therapeutic approach (4).

METHODS

Case Description

A 41-year-old woman was referred to our center for intractable pain due to pectoral metastasis from ductal mammary carcinoma NAS G3, ER-negative, PgR-negative, Her2-negative, Ki-67 70%. She underwent chemotherapy and then, in December 2021, a skin-sparing unilateral mastectomy.

New chemotherapy followed, and in February 2022, a metastasis was found in the pectoral muscle and in the intravenous hepatic segment. Chemotherapy was able to control the progression in the liver; whereas, the pectoral lesion continued to grow (Fig. 1).

We first met with the patient in August 2022. At that time, her pain was rated at 9/10 on the Numeric Rating Scale (NRS-11), with a Douleur Neuropathique 4 Questionnaire neuropathic score of 7. The patient complained of sharp, burning, continuous pain in the right arm related to compression of the brachial plexus. No motor deficit was observed. Allodynia and painful hypoesthesia were present distal to the elbow.

We suggested an incremental dose of pregabalin, which resulted in side effects. Tramadol 50 mg twice a day was also not well tolerated and was ineffective. Oral morphine was then started at 10 mg 6 times a day (double dose at nighttime), along with ibuprofen 600 mg 3 times a day and prednisone 25 mg. This resulted in an improvement of 2 points on the NRS-11 at rest, but led to the occurrence of refractory opioid-induced bowel dysfunction. At the same time, a block of the brachial plexus with lidocaine 0.5% 10 mL under ultrasound guidance was performed, resulting in the sudden disappearance of pain for 12 hours.

Pain scores were reported with the NRS-11 at 8/10 before the implant. Functionality measured with the Oswestry Disability Index (ODI) was 66%, QoL with the EuroQoL 5-Dimension 5-Level Version (EQ-5D-5L) was 24444 (value set for Spain 0.095 utility index, value set for United States 0.349), and with the QoL 20%. In January 2023, the patient received a permanent Freedom PNS System.

Device Description

The Freedom PNS System uses HF-EMC technology. It includes an implanted electrode array (with 4 or 8 contacts), a separate implanted receiver, an external transmitter assembly, and a wearable accessory. The Freedom PNS System is comprised a 2-component implant that the physician connects during the procedure (Fig. 2). The physician is also required to create a pocket.

Permanent Implant Surgical Technique

Informed consent was obtained and the patient was taken to the operating room and appropriately positioned supine on the table. The implant site was cleaned and covered with sterile drapes. The needle entry point and pathway were planned using ultrasound and fluoroscopy. The skin and deeper tissues were anesthetized using a local anesthetic. The initial introducer path was also infiltrated with a local anesthetic. The first incision was made with an 11-blade scalpel in the right lateral clavicular region, and the 13G introducer needle was passed through the incision and advanced subcutaneously in the fascial plane toward the supraclavicular

brachial plexus using small amounts of local anesthetic. A 4-contact electrode array with tines was inserted through the cannula and advanced to the subclavian region (Fig. 3).

A receiver pocket was created using blunt dissection through a second incision. The steering stylet was removed from the previously implanted electrode array, and a separate receiver was connected to the electrode array. The electrode array and receiver were tunneled beneath the skin from the first incision to the second incision receiver pocket. A knot was tied to permanently connect the separate receiver and electrode array. The receiver was coiled into a small diameter and 2 nonabsorbable sutures were used to permanently form the receiver coil. The end of the receiver coil was tucked underneath the coil to avoid protruding edges. Using a nonabsorbable suture, the receiver coil was sutured to the fascia in 2 locations, ensuring it was flat in the pocket. The receiver pocket was closed with deep and superficial absorbable sutures.

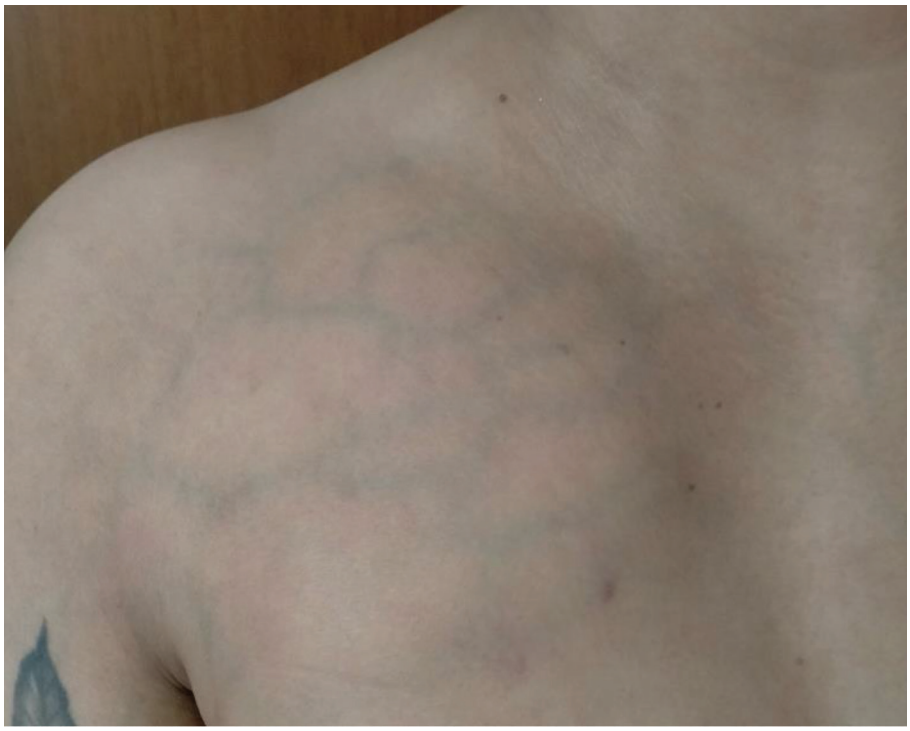

Fig. 1. Pectoral lesions.

The patient was programmed using paresthesia-free stimulation patterns with a frequency of 1,499 Hz with amplitudes of 1.2-1.5 mA. The patient used the Freedom PNS System for 14 hours per day.

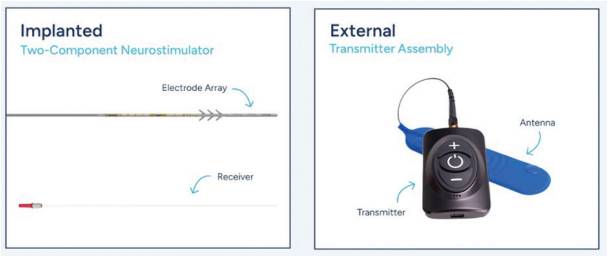

Fig. 2. Freedom PNS system.

RESULTS

After 7 days, the ODI was 12%, QoL was 100%, EQ-5D-5L was 22211 (value set for Spain 0.720 utility index, value set for the United States 0.799), and NRS-11 was 2/10 (mainly for chemotherapy-related symptoms). All drugs were stopped, except for ibuprofen 600 mg when needed.

We followed the patient as needed by telephone and with scheduled visits. There was no necessity for reprogramming as the patient continued to report improved pain relief. The improvement was maintained for 4 months postpermanent implant.

After 4 months, abdominal pain related to multiple metastases occurred. The patient was prescribed opioids by the oncologist, and eventually, 20 days later, the patient passed away due to multiple organ failure.

DISCUSSION

The use of neurostimulation devices in refractory cancer pain patients is mostly limited to spinal cord stimulation (SCS) with different indications and effectiveness (3). However, the use of PNS has become an increasingly relevant and valuable option for managing neuropathic pain and also cancer-related pain, particularly in cases where traditional treatments are ineffective. The mechanism of action of PNS involves delivering electrical impulses to peripheral nerves,

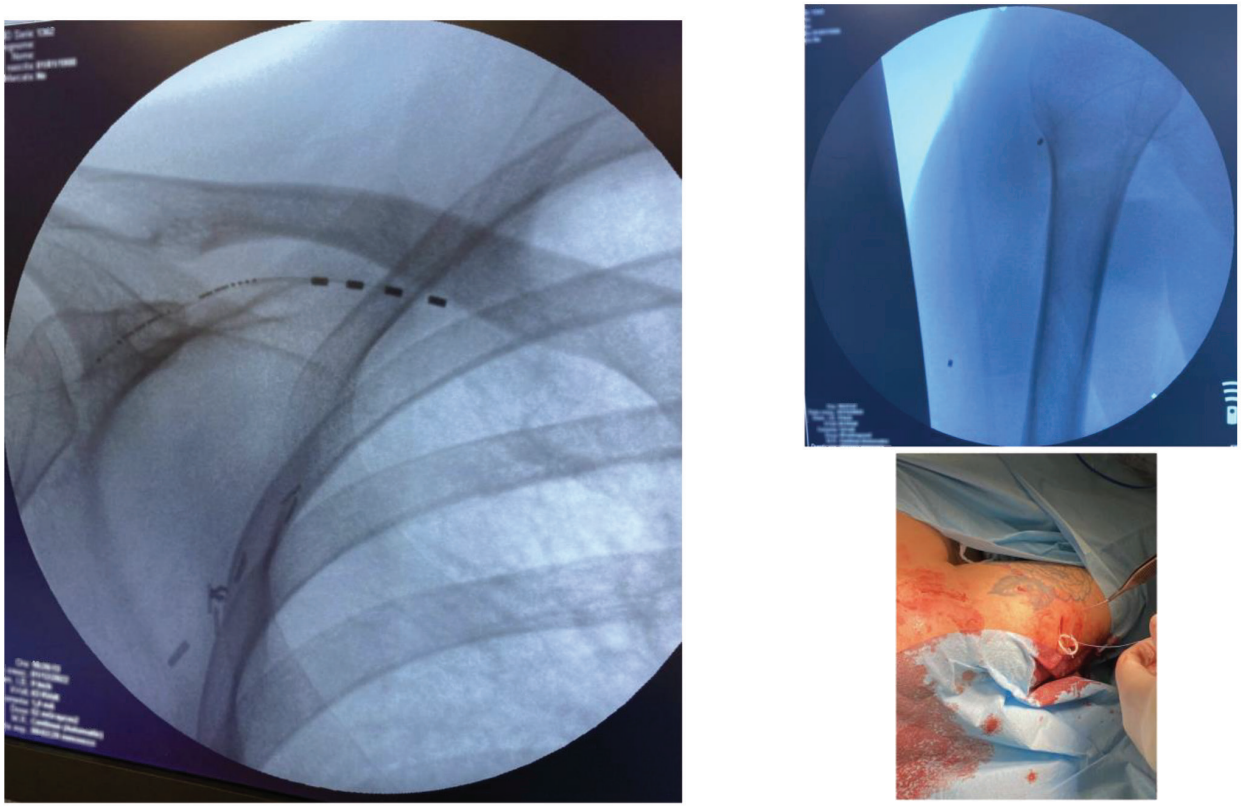

Fig. 3. Fluoroscopy of device positioning.

which can modulate pain signals before they reach the central nervous system (1). This method is particularly useful for patients with localized neuropathic pain due to cancer invasion or metastasis, which can cause significant discomfort and reduced QoL.

In the presented case, the patient suffered from severe, intractable pain due to pectoral metastasis from ductal mammary carcinoma. Despite multiple pharmacological interventions, her pain remained poorly controlled, and the side effects of the medications significantly impacted her QoL. The introduction of the Curonix Freedom PNS System provided substantial pain relief. It improved her overall functionality and QoL, even if only temporarily, as evidenced by the marked improvement in her NRS-11 score, ODI score, and EQ-5D-5L utility indexes.

Traditional analgesic treatments for cancer pain, such as opioids and nonsteroidal anti-inflammatory drugs, often come with significant side effects, including sedation, constipation, and the potential for dependency. Moreover, these medications may not always provide adequate pain relief, especially in cases of neuropathic pain where the pain pathways are altered. PNS offers an alternative by targeting the pain at its source with no systemic side effects (5). This is particularly important for cancer patients who are often already dealing with multiple medications and side effects from their primary cancer treatments (4-6).

A study conducted by Tate et al (7) has demonstrated the potential advantages of PNS for injured brachial plexus nerve roots. The research emphasized the significant pain relief achieved through PNS targeting the median nerve (7).

Studies (8) have also shown significant pain relief following procedures like total knee arthroplasty and amputation.

One key advantage of PNS is the ability to tailor the treatment to the individual patient's needs. In this case, an externally powered system with high-frequency paresthesia-free stimulation parameters was guided by magnetic resonance imaging (MRI) conditionality and the patient's specific pain characteristics (5). This personalized approach ensures that the treatment aligns with the patient's overall treatment plan and lifestyle.

A positive response to a local anesthetic injection suggested the possibility of a more-tailored treatment. A cervical SCS was considered, but the patient refused to implant the generator if an alternative was possible. When planning the implant procedure, we were concerned that the wearable antenna had to be positioned on the arm where the pain was partially present. The electrode array was placed in the infraclavicular position and we decided, together with the patient, that the arm would be an appropriate place to position the transmitter assembly.

We had to make a choice whether to use an externally powered system capable of subthreshold stimulation parameters (Freedom PNS) or a tonic mini-implantable pulse generator (IPG) stimulator (Neurimpulse, Padua, Italy). The mini-IPG stimulator has the advantage of a low-profile implantable primary cell generator that could bypass the aforementioned problem of the wearable antenna. However, we opted for the former due to its MRI conditionality and the possibility of using subthreshold stimulation (9).

HF-EMC technology in the Curonix Freedom PNS System allows for precise modulation of pain signals with adjustable stimulation parameters. The procedure for implanting the PNS system is minimally invasive compared to other surgical options, such as SCS, and offers greater flexibility in implant location, enhancing patient comfort and compliance (10).

The success of the Freedom PNS System underscores the importance of considering PNS for patients with chronic cancer-related pain that is unresponsive to conventional therapies.

This case study reports a patient with cancer-related pain, where a single and well-defined lesion was responsible for 90% of the pain and disability. Systemic drugs were unable to control this kind of pain and were also poorly tolerated. The incremental benefit of this treatment was scarce.

The benefit obtained after positioning the electrode array was demonstrated by the increment of 0.625 on the utility index (EQ-5D-5L from 0.095 to 0.720) and the reduction of disability measured by the ODI score while discontinuing all opioids. This success is achievable only with the right diagnosis and appropriate treatment tools.

CONCLUSIONS

PNS at the supraclavicular brachial plexus is considered an effective and safe therapy for treating patients with chronic pain due to cancer, which has been resistant to conservative therapy. The use of this system allowed for the best possible outcome for the last 4 months of this patient's life. This therapy can be considered for patients with limited surgical options.

Acknowledgment

We would like to acknowledge and thank the Curonix Clinical team for their participation in writing, data analysis, and technical editing of the manuscript.

REFERENCES

1. Abd-Elsayed A, Attanti S, Anderson M, Dunn T, Maloney J, Strand N. Mechanism of action of temporary peripheral nerve stimulation. *Curr Pain Headache Rep* 2023.
2. Kim JY, Jeon JY, Choi YJ, et al. Characteristics of metastatic brachial plexopathy in patients with breast cancer. *Support Care Cancer* 2020; 28:1913-1918.
3. Crowther JE, Chen GH, Legler A, Gulati A. Spinal cord stimulation in the treatment of cancer pain: A retrospective review. *Neuromodulation* 2022; 25:693-699.
4. Helm S, Shirsat N, Calodney A, et al. Peripheral nerve stimulation for chronic pain: A systematic review of effectiveness and safety. *Pain Ther* 2021; 10:985-1002.
5. Abd-Elsayed A. Wireless peripheral nerve stimulation for treatment of peripheral neuralgias. *Neuromodulation* 2020; 23:827-830.
6. Pollina R, Betanzons G, Abd-Elsayed A. Peripheral nerve stimulation with a high-frequency electromagnetic coupled powered implanted receiver at the posterior tibial nerve for the treatment of chronic pain in the foot. *Neuromodulation* 2024; 27:126-129.
7. Tate Q, Pagan-Rosado R, Hallo-Carrasco A, Hurdle MFB. Peripheral nerve stimulation for chronic intractable neuropathic pain following a brachial plexus avulsion injury: A case report. *A A Pract* 2023; 17:e01681.
8. Xu J, Sun Z, Wu J, et al. Peripheral nerve stimulation in pain management: A systematic review. *Pain Physician* 2021; 24:E131-E152.
9. Abd-Elsayed A, D'Souza RS. Peripheral nerve stimulation: The evolution in pain medicine. *Biomedicines* 2021; 10:18.
10. Ong Sio LC, Hom B, Garg S, Abd-Elsayed A. Mechanism of action of peripheral nerve stimulation for chronic pain: A narrative review. *Int J Mol Sci* 2023; 24:4540.