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Externally Powered Peripheral Nerve Stimulator With a Separate Receiver at the Median Nerve for the Treatment of Postoperative Carpal Tunnel Release-Related Chronic Pain in the Upper Extremity: A Case Report

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Background: Chronic pain in patients with multiple overlapping pain syndromes is often refractory to conventional treatments. Peripheral nerve stimulation (PNS) has emerged as a promising neuromodulation therapy, especially when spinal cord stimulation (SCS) is contraindicated or ineffective.

Case Report: We present the case of a 68-year-old man with severe chronic pain in the left hand and wrist following carpal tunnel release surgery, superimposed on a background of cervical and lumbar radiculopathies, degenerative cervical spondylosis, sacroiliitis, and failed back surgery syndrome. Conservative therapies (including transcutaneous nerve stimulation, physical therapy, injections, and opioids) as well as an intrathecal pump and a thoracolumbar SCS trial were moderately successful in relieving chronic back pain but had failed to relieve his hand pain. The patient was not a candidate for a cervical SCS due to extensive cervical spondylosis and stenosis. The patient underwent a 10-day trial of an externally powered PNS system targeting the left median nerve at the wrist, achieving > 50% pain reduction. This was followed by permanent implantation of the PNS device. The intervention produced an immediate pain score reduction from 9/10 to 4/10, and at 12 months postimplant, the patient reported complete pain relief (0/10) with restored hand function, improved sleep, and quality of life. No device-related complications occurred, and no reprogramming was required.

Conclusions: In this complex pain patient, the externally powered Freedom® Peripheral Nerve Stimulator System provided effective, focal analgesia where other therapies (including SCS) were not effective or viable, highlighting the potential of PNS as a safe and efficacious treatment for postsurgical neuropathic pain of the upper extremity.

Key words: Peripheral nerve stimulation, chronic pain, median nerve, upper extremity, wrist pain, carpal tunnel syndrome

BACKGROUND

Chronic pain is a complex, multifaceted clinical challenge that impairs physical function and quality of life. Its multifactorial nature, often involving multiple coexisting pain generators, demands a comprehensive, multimodal treatment approach. In recent years, peripheral nerve stimulation (PNS) has established itself as an important treatment modality for managing chronic

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pain conditions that are refractory to conservative measures. PNS has been utilized in a wide spectrum of clinical scenarios, from isolated peripheral mononeuropathies and entrapment neuropathies to more diffuse or complex pain syndromes, such as peripheral nerve injuries, phantom limb pain, complex regional pain syndrome, chronic back pain, and fibromyalgia. This breadth of applications is facilitated by the relative ease of placing an electrode array near the affected nerve, allowing for targeted neuromodulation with high patient compliance and minimal systemic effects.

The theoretical basis for PNS's analgesic effect is rooted in the classic gate control theory proposed by Melzack et al (1) in the 1960s. According to this theory, stimulating large-diameter afferent fibers (Aβ fibers) can "close the gate" to nociceptive signals at the spinal dorsal horn, thereby inhibiting pain transmission (1). In practice, PNS-induced neuromodulation likely operates through both peripheral and central mechanisms to dampen pain perception. While the exact mechanisms remain only partially understood, accumulating clinical experience underscores that PNS can provide meaningful pain relief for patients who do not respond to pharmacological therapy or other interventions (2).

Carpal tunnel syndrome (CTS) is a common peripheral entrapment neuropathy, and surgical release is typically effective in relieving median nerve compression. However, a subset of patients can develop chronic postsurgical neuropathic pain in the hand and wrist despite a technically successful carpal tunnel release. Our patient, a 68-year-old man, exemplified such a scenario. His case was further complicated by multiple pain comorbidities, including cervical radiculopathy with myelopathy, cervical spondylosis, lumbar radiculopathy, postlaminectomy syndrome, sacroiliitis, and knee osteoarthritis. Notably, CTS is the most frequent entrapment neuropathy globally and usually presents with numbness, tingling, and nocturnal paresthesias in the radial 3½ digits; diagnosis is clinical, with nerve conduction studies reserved for ambiguous cases (3). In this patient, despite prior left carpal tunnel release surgery, severe neuropathic pain persisted in the median nerve distribution.

Standard therapies for his chronic pain—such as transcutaneous electrical nerve stimulation (TENS), physical therapy, epidural steroid injections, opioid analgesics, and even an intrathecal morphine pump—failed to provide lasting relief. A spinal cord stimulation (SCS) trial (with thoracolumbar lead placement) was undertaken and did yield partial improvement of his low back pain; however, it did not alleviate the dominant hand and wrist pain. A cervical SCS trial was contraindicated given his extensive cervical spondylosis and stenosis, which increased the risk of procedural complications. Facing these limitations, we pursued an alternative strategy using externally powered PNS of the median nerve at the wrist.

This case report details the successful treatment of chronic postcarpal tunnel release pain with an externally powered PNS system, in a patient who had exhausted other options. We also reviewed relevant literature to highlight the unique value of PNS in such complex pain presentations. To our knowledge, this is one of the first reports of PNS completely resolving upper-extremity neuropathic pain in a patient with multiple comorbid pain syndromes and contraindications to SCS. It underscores the importance of tailoring pain management to individual neuroanatomy and comorbidities, and suggests that externally powered PNS is a considerable tool for the treatment of focal neuropathic pain where conventional neuromodulation or surgical approaches are not feasible.

METHODS

Case Description

A 68-year-old man was referred to our pain clinic for intractable left-hand and wrist pain. His medical history was notable for left CTS (status post [s/p] surgical release), cervical radiculopathy with cervical spondylosis (multilevel degenerative changes and stenosis), degenerative cervical myelopathy, lumbar radiculopathy (with chronic low back pain, s/p lumbar laminectomy 2 years prior), postlaminectomy syndrome (failed back surgery syndrome with persistent pain), sacroiliitis, and bilateral knee osteoarthritis. The patient's chief complaint was severe neuropathic pain radiating from the left wrist into the hand and fingers, which had persisted for over 2 years after his carpal tunnel release surgery. He described the pain as continuous stabbing, burning, shooting, and tingling sensations in the median nerve distribution. On examination, there was no motor deficit in the hand (grip strength and thenar muscle bulk were preserved), but there was marked sensory disturbance: the patient exhibited allodynia and painful hypoesthesia over the median-innervated digits of the left hand.

The patient had undergone an extensive range of treatments for his multifocal pain without success. Conservative measures, including TENS, physio-

therapy, and activity modification, failed to improve his hand pain. He required long-term opioid therapy and had an intrathecal pump for morphine, which helped somewhat with lower back and leg pain but not the hand symptoms. Interventional treatments, such as cervical facet, radiofrequency ablation, and epidural steroid injections, provided only temporary relief. Given his prior lumbar spine surgery and ongoing low back pain, a trial of SCS was performed with leads placed in the thoracolumbar epidural space; this trial provided approximately 50% relief of his lower back and leg pain, but no appreciable relief of the left-hand pain. Since high cervical spinal stimulation was considered too risky in the context of his cervical spondylotic myelopathy, an SCS targeting the cervical region was not attempted. Thus, by the time of referral, his debilitating left-hand pain remained essentially untreated by available modalities, significantly impairing his daily function and sleep. At presentation, the patient rated his baseline pain as 9/10 on the Numeric Rating Scale (NRS-11). Given the focal, neuropathic nature of the pain (presumed due to median nerve injury or scarring after carpal tunnel release) and the failure of both conservative management, intrathecal pump, and SCS, we proposed a trial of an externally powered PNS targeting the left median nerve. After discussion of risks, benefits, and alternatives, the patient consented to a PNS trial. A percutaneous PNS system was placed along the left median nerve at the wrist under ultrasound guidance (described in detail below) for a 10-day trial period. During this trial, the patient reported > 50% reduction in his hand pain, with his NRS-11 pain score improving to 4/10. Encouraged by this result, we proceeded with permanent implantation of the Freedom® PNS System (Curonix LLC, Pompano Beach, FL).

Device Description

The PNS system used in this patient (Freedom PNS System by Curonix LLC, Pompano Beach, FL) includes an implanted electrode array (with 4 or 8 contacts), a separate implanted receiver, as well as an external transmitter assembly and wearable accessory (Fig. 1). The external transmitter uses high-frequency electromagnetic coupling technology to wirelessly transfer data and power to the 2-component implant that the physician connects during the procedure. The physician must also create a separate pocket to anchor the device permanently.

Permanent Implant Surgical Technique

The permanent implantation was performed under local anesthesia with ultrasound and fluoroscopic guidance. The patient was positioned supine on the operating table (with the left arm extended), and the planned incision sites were infiltrated with lidocaine. Using real-time ultrasound, we identified the left median nerve at the distal forearm near the wrist crease, as well as a viable subcutaneous trajectory for the electrode array. An 11-blade was used to make a stab incision and a 13 G introducer needle was advanced subcutaneously in the fascial plane of the forearm, directed toward the left wrist. Intermittent ultrasound and fluoroscopy were used to guide the needle's course toward the vicinity of the left distal radius and wrist. Incremental local anesthetic was administered along the needle path to expand the plane. Once the needle tip reached the target area near the median nerve at the wrist, a flexible 4-contact electrode array (with small anchoring tines) was inserted through the introducer cannula. Under fluoroscopic visualization, the electrode array was advanced until the distal contacts were positioned adjacent to the median nerve at the level of the distal forearm. The introducer was then withdrawn, and the electrode array secured in place (Fig. 2).

A subcutaneous 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 connect the separate receiver and electrode array permanently. The receiver was coiled, and 2 nonabsorbable sutures were used to form the receiver coil permanently. 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.

The patient was programmed using paresthesia-free stimulation (subthreshold stimulation, not producing sensory response) at a frequency of 1,499 Hz.

RESULTS

Within hours of activation of the permanent PNS implant, the patient reported a dramatic improvement in his hand pain, consistent with what he had experienced

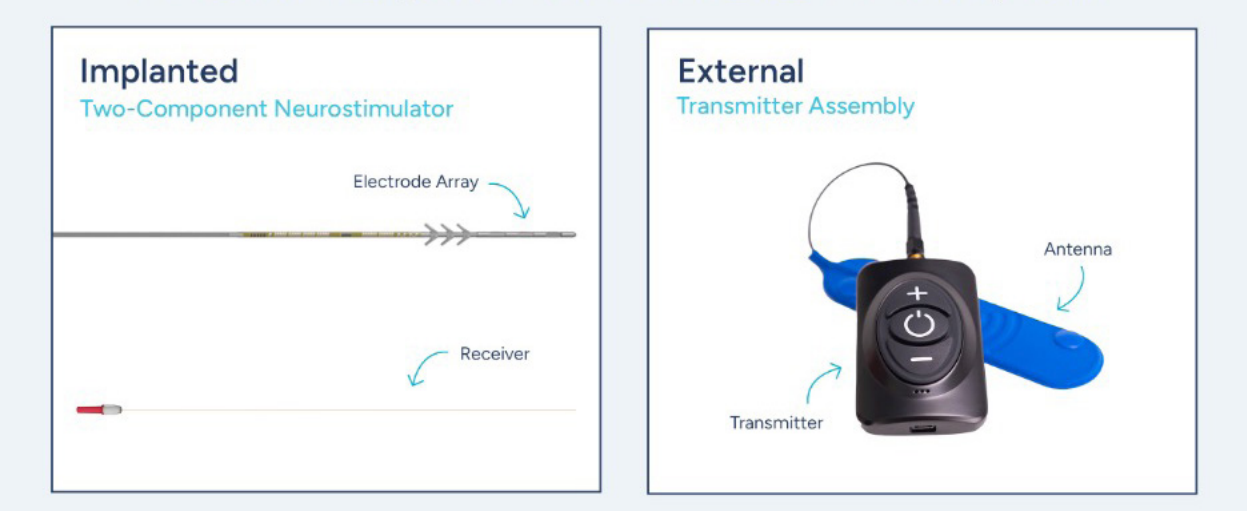

Fig. 1. Freedom PNS System.

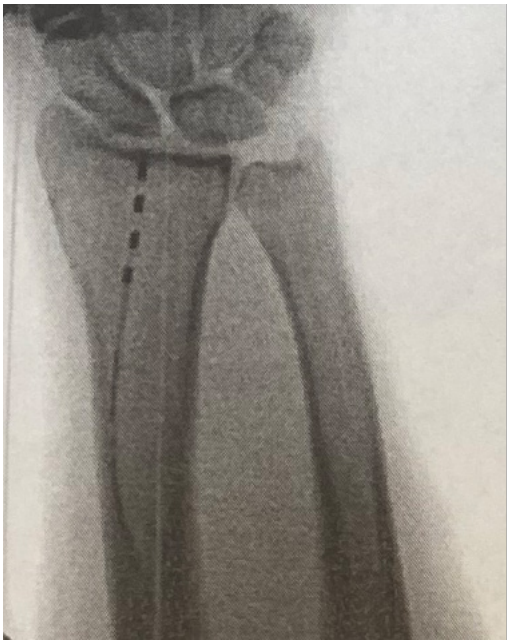

Fig. 2. Fluoroscopy of device positioning.

during the trial. Pain scores dropped from 9/10 at baseline to 4/10 immediately after the PNS trial placement, and further improved to 0/10 after the permanent implant was in place. At the 12-month follow-up, the patient continued to report complete pain relief in the left hand and wrist, equating to a 100% improvement in that pain component. He had discontinued all opioid analgesics for hand pain (though he still required low-dose opioids for intermittent back pain flares) and noted that his sleep quality and daily functioning had significantly improved. Throughout the follow-up period, no adverse events or complications occurred. The device remained stable; notably, no reprogramming of stimulation parameters was required over the 12 months, as the patient remained pain free with the initial programming settings. In addition, the patient expressed satisfaction with the therapy and indicated willingness to consider PNS implantation for some of his other pain syndromes (such as the contralateral hand or lower extremity) in the future. This positive outcome highlights both the efficacy and durability of the PNS treatment in this case. No complications were reported.

DISCUSSION

The successful outcome in this patient reflects the growing role of PNS in chronic pain management. A significant increase in the body of literature supports the utility of PNS across a range of chronic pain conditions. Unlike SCS, which requires epidural lead placement and typically an implantable pulse generator, PNS is an approach that allows precise targeting of peripheral nerves under ultrasound or fluoroscopic guidance. By activating selected Aβ fibers at the peripheral nerve level, PNS can modulate upstream nociceptive signaling and reduce pain perception. This neuromodulatory effect aligns with the gate control paradigm and other mechanism-of-action insights from recent research (2). Clinically, PNS offers the advantage of being focal—it can be directed at a specific nerve that corresponds to the patient's pain,

thereby minimizing systemic side effects and interactions with other implanted devices.

Multiple studies and systematic reviews (4-12) have documented the safety and effectiveness of PNS in various chronic pain syndromes. For example, PNS has shown significant benefit in chronic low back pain associated with neuropathic leg pain (radiculopathy) (13) and in chronic neuropathic pain of the lower extremities (such as foot or knee pain) (14). In one systematic review (13) of PNS for pain management, positive outcomes were also noted for conditions like postamputation phantom limb pain and craniofacial neuropathic pain, underscoring the broad applicability of this technique. Overall, evidence suggests that when PNS is appropriately applied to a suitable nerve target, a majority of patients achieve meaningful pain relief and functional improvement. This is especially encouraging given that many of these patients have failed conventional therapies and often have limited remaining options.

One particularly challenging pain entity is failed back surgery syndrome, now often termed persistent spinal pain syndrome type 2 (PSPS-T2). Patients with PSPS-T2 experience chronic back and leg pain after spine surgery, frequently due to issues, such as residual neural compression, epidural fibrosis, or nerve root injury (15). Traditional management of postlaminectomy syndrome may involve repeat surgery or SCS; however, these approaches are not always feasible or successful. Notably, interventional pain treatments can still provide relief in this population: for instance, nearly half of postlaminectomy patients can achieve at least 50% pain reduction with comprehensive pain management strategies that include neuromodulation and injections. PNS has been explored as an adjunct or alternative in PSPS-T2 for cases where SCS is ineffective or contraindicated. By targeting peripheral nerves, PNS can address localized elements of pain without necessitating spinal instrumentation. In our patient, who had postlaminectomy syndrome contributing to his pain burden, the PNS was directed at a peripheral nerve (median nerve) unrelated to his back surgery—yet the success of this approach in relieving his hand pain illustrates how addressing one pain generator can dramatically improve overall quality of life even if other pain sources persist at a manageable level.

In the context of this complex clinical background, our patient's case demonstrates the unique value of PNS for focal neuropathic pain. He had multiple pain comorbidities (cervical, lumbar, and sacroiliac pathology) that complicated his overall pain picture, yet the most debilitating symptom for his daily life was the hand pain following carpal tunnel release. Traditional approaches had failed to control this focal pain, and SCS, the usual next step for neuropathic limb pain, was not viable in the cervical region due to anatomical risks. By deploying externally powered PNS at the median nerve, we were able to provide a solution that was minimally invasive, targeted, and effective. The patient's hand pain completely resolved with the PNS implant and remained absent through one year of follow-up, which is a remarkable outcome given the refractory nature of his pain. Importantly, this was achieved without exacerbating his other pain conditions and without causing any new neurological deficits. The externally powered PNS system was well tolerated and did not interfere with his intrathecal pump or any other devices.

This case underscores that PNS serves as a viable alternative when SCS is contraindicated or insufficient, particularly for patients with localized neuropathic pain. It also highlights the importance of a tailored pain management strategy: rather than focusing on his spine issues (which were being managed separately), we targeted the primary pain generator that mattered most to the patient's quality of life. As seen here, the result was an excellent analgesic outcome and significant improvement in the patient's overall well-being. Moving forward, as PNS technology and techniques continue to advance, we anticipate it will play an increasingly important role in personalized pain management, complementing other modalities. Cases like this add to the growing evidence that PNS can achieve complete pain resolution in select patients, thereby reducing reliance on opioids and improving function in those who have exhausted standard treatments.

CONCLUSIONS

In summary, externally powered PNS of the median nerve proved to be a safe and highly effective therapy for chronic, post-carpal tunnel release neuropathic pain in the upper extremity. This case demonstrates that PNS is able to provide targeted pain relief and even full pain resolution in a scenario where conservative management failed and SCS was not an option. Externally powered PNS offers a minimally invasive alternative for patients with localized neuropathic pain, avoiding the risks associated with more invasive surgical or neuromodulatory procedures. With a growing body of clinical evidence supporting its use, PNS has the potential to improve functional outcomes, reduce opioid dependence,

and enhance quality of life in appropriately selected patients suffering from chronic pain syndromes. For pain specialists and surgeons, PNS should be considered as an integral component of a multimodal pain management plan, especially for patients with focal pain who are not candidates for conventional neuromodulation like SCS. This case adds to the literature by highlighting the successful application of PNS in a postsurgical neuropathic pain condition and encourages further adoption of peripheral neuromodulation techniques in chronic pain management.

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