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CASE REPORT
Peripheral Nerve

Permanent Peripheral Nerve Stimulator for Complex Regional Pain Syndrome of the Forearm and Hand

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Summary: A 51-year-old woman with diabetes and depression was referred to the anesthesia pain clinic with a 15-year history of complex regional pain syndrome type I of the right forearm and hand in the radial sensory nerve distribution. There was no recognized antecedent trauma and she had failed both medical treatment and radial sensory nerve decompression surgery. An ultrasound-guided local anesthetic block of the radial nerve in the upper arm resulted in partial and temporary improvement in pain. She subsequently underwent trial of a peripheral nerve stimulator (PNS) followed by permanent PNS implant placement over the radial nerve proper proximal to the elbow. Within the first month of use, she endorsed substantially improved pain and strength in her right hand. These improvements were sustained for more than 1 year. Applications of PNS technology for treatment of extremity complex regional pain syndrome and neuropathic extremity pain in general are reviewed. *(Plast Reconstr Surg Glob Open 2024; 12:e5764; doi: 10.1097/GOX.0000000000005764; Published online 17 May 2024.)*

Complex regional pain syndrome is a neuropathic pain disorder characterized by disabling pain disproportionate in magnitude and/or duration to the inciting tissue trauma. The condition is typically precipitated by trauma but can occur without a recognized cause. Symptoms, physical manifestations, and radiographic findings in an affected extremity include pain, swelling, sudomotor and vasomotor abnormalities, tissue atrophy, joint stiffness, and bone demineralization.[1]

In complex regional pain syndrome (CRPS) type I, there is a small nociceptor fiber neuropathy without clear nerve damage. In CRPS type II, there is a discernible nerve injury. The pathophysiology, clinical course, and ideal treatment of CRPS remain uncertain. We describe a case of CRPS type I in the radial sensory nerve distribution in the forearm and hand that evaded conventional medical and surgical management but responded to peripheral nerve stimulator (PNS) implantation. Informed consent was obtained from the patient for this report.

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CASE REPORT

A 51-year-old right-hand–dominant woman with a history of diabetes and depression was referred by a hand surgeon to the anesthesia pain clinic in 2019 for management of intractable CRPS type I in the radial sensory nerve distribution in her right forearm and hand. Failed treatment measures over several years included splinting, hand therapy, oral and topical medications, and corticosteroid injections (thumb joints, carpal tunnel, and adjacent to the radial sensory nerve). Surgical decompression of the radial sensory nerve with nerve tube wrapping provided no meaningful symptom improvements.

The patient described burning numbness and electrical shock sensations in the dorsal aspect of her right forearm and hand, numbness and tingling in the proximal interphalangeal joint region of each finger, and weakness of grasp. Cold weather, touch, and stress worsened her pain. Radiographs and magnetic resonance imaging (MRI) of her right hand revealed no marked abnormalities. A right forearm ultrasound study showed nonspecific fluid around the radial sensory nerve. A cervical spine

Disclosure statements are at the end of this article, following the correspondence information.

MRI demonstrated mild spondylosis and degenerative disc disease at C4/C5 and C5/C6. An upper extremity electrodiagnostic study revealed no evidence of cervical radiculopathy, peripheral nerve entrapment, or large fiber sensorimotor polyneuropathy.

In December 2019, the patient underwent a cervical epidural steroid injection at C7/T1, which was ineffective. The following month, she received a test injection of bupivacaine and dexamethasone adjacent to the radial nerve proper in her right upper arm. The injection resulted in partial and transitory pain relief. In February 2020, she returned to clinic for trial implantation of a PNS.

Trial PNS Implantation

An ultrasound probe (ML6-15 probe, GE Healthcare) covered by sterile plastic was used to locate the radial nerve proper in the mid-to-distal third of her antiseptic prepared right upper arm (Fig. 1).[2] Under local anesthesia, a small skin incision was made and the introducer complex for the PNS [StimQ Peripheral Nerve Stimulator, Stimwave Technologies, Inc. (acquired by Curonix LLC and rebranded Freedom Peripheral Nerve Stimulator)] was advanced distally at a shallow angle under ultrasound guidance, superficial to the radial nerve proper and ending proximal to the elbow (Fig. 2).

The rigid introducer was withdrawn, leaving the soft-tipped introducer in position, and an electrode array from the Stimwave kit was inserted (Figs. 3 and 4). The soft-tipped introducer was removed and the antennae lead was secured externally to skin. Confirmation of acceptable wire placement was performed with electrode stimulation: sensations of tingling, tapping, and buzzing were elicited

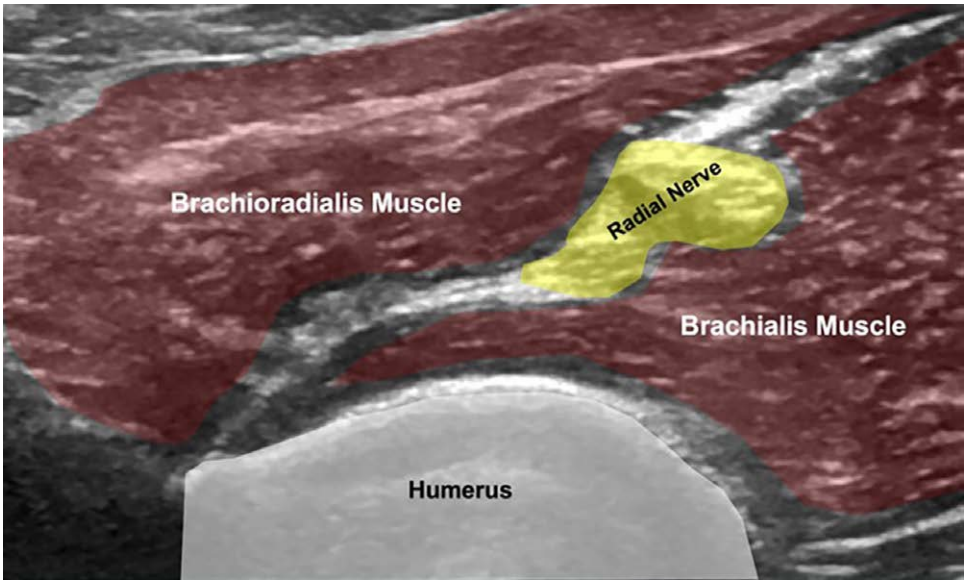

Fig. 1. Axial ultrasound view of the radial nerve in the lower third of the upper arm.

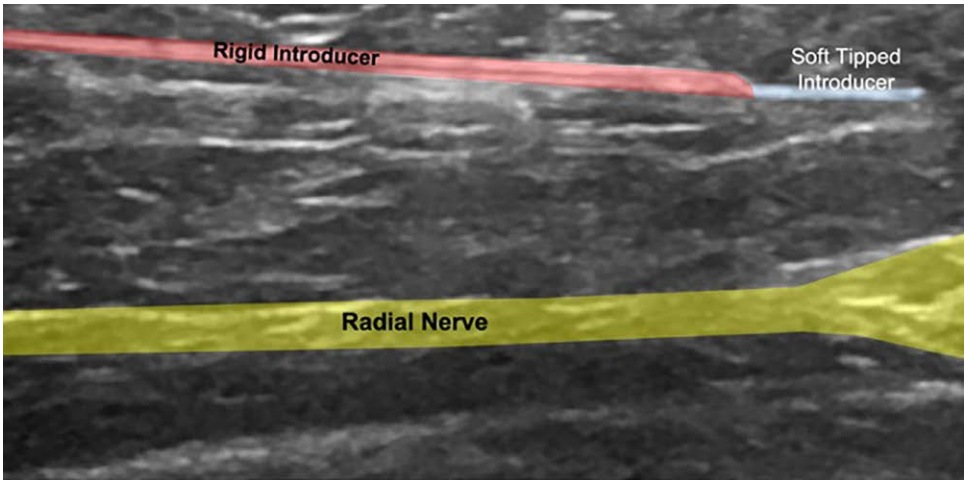

Fig. 2. Longitudinal ultrasound view of the PNS rigid introducer positioned superficial to radial nerve proper in the lower third of the upper arm.

Fig. 3. PNS kit [StimQ Peripheral Nerve Stimulator, Stimwave Technologies, Inc. (acquired by Curonix LLC and rebranded Freedom Peripheral Nerve Stimulator)]

in the distribution of the radial sensory nerve and without visible muscle contractions. There were three amplitude settings of 1 mA, 2.5 mA, and 3 mA; each amplitude was locked at a frequency of 1499 Hz and a pulse width of 30 microseconds. The skin incision was closed and a charging device was strapped around the upper arm.

Permanent PNS Implantation

One week later, the patient endorsed more than 50% reduction of pain in her right forearm and hand. A permanent radial nerve PNS was implanted after 2 months using similar procedural steps; however, the antennae was buried below skin. The final PNS waveform settings were the same as the trial settings, permitting the patient to vary amplitudes from 1 mA to 3 mA. Four weeks post PNS implantation, the patient reported more than 80% reduction in pain and improved hand strength. These subjective improvements were maintained at 1.5-year follow-up.

DISCUSSION

Peripheral nerve stimulation can be used to treat refractory neuropathic pain through focused delivery of electrical impulses to a single nerve proximal to the site of pain.[3,4] According to the Gate-Control hypothesis, PNS inhibits ascending noxious impulses from nociceptors through nonpainful stimulation of large diameter sensory fibers. Other physiologic mechanisms, such as collision of ortho- and antidromic activity in Aβ nerve fibers, may also contribute to PNS efficacy.[5]

Peripheral nerve stimulation has had limited adoption likely due to a variety of factors, including cumbersome designs of early devices, regulatory approval requirements, inconsistent reimbursement, sparse accessibility of pain management physicians with experience in PNS implantation, and limited surgeon awareness of this technology. Conceivably, recognized surgical techniques to treat painful neuromas may dissuade interest in PNS.

There are few median- to long-term outcome studies on the use of PNS in treating neuropathic extremity pain. In a prospective series of 30 patients with upper or lower extremity CRPS (presumably type I), Hassenbusch et al[6] reported good or fair pain relief in 19 patients at 2- to 4-year follow-up. In a retrospective chart review of 165 patients with CRPS type I or II of the upper or lower extremity, Chmiela et al[7] found a small but significant decrease in pain scores at 12-month follow-up. In a recent systematic review of PNS, The American Society of Pain and Neuroscience concluded that this treatment modality is associated with modest to moderate relief of chronic pain.[8]

More outcomes research on PNS in the treatment of neuropathic extremity pain and greater awareness among hand and peripheral nerve surgeons of this technology are warranted. Currently marketed PNS devices are more compact in design than earlier devices, often MRI compatible, and relatively straightforward to operate.[3] In select

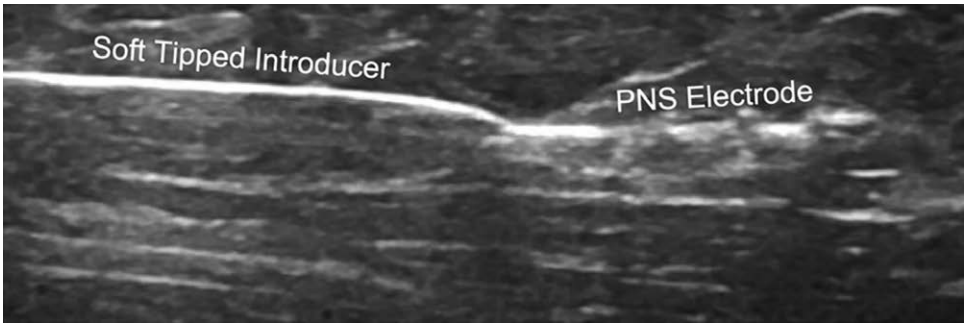

Fig. 4. Longitudinal ultrasound view of the soft-tipped introducer with the PNS electrode extending superficially over the radial nerve proper in the lower third of the upper arm.

cases, a PNS device may be a viable and long-term adjunct or alternative treatment to refractory neuropathic extremity pain.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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