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Treatment of Complex Regional Pain Syndrome of the Knee With Peripheral Nerve Stimulation After Failed Dorsal Root Ganglion Stimulation

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Background: Complex regional pain syndrome (CRPS) is a chronic progressive neuropathic condition that generally presents following trauma, surgical procedures, or develop spontaneously. Clinical recommendations are to pursue early, multifactorial treatment modalities, such as physical therapy, psychotherapy, along with medications. If conservative treatment becomes insufficient, interventional treatments, such as dorsal root ganglion (DRG) stimulation and peripheral nerve stimulation (PNS), have been proven effective measures in treating the condition.

Case Report: A 44-year-old woman, who underwent multiple knee surgeries originally for osteoarthritis, developed CRPS Type II around her right knee. A L3/L4 DRG stimulator was implanted after conservative treatment failed. She reported 50% improvement and reduced opioid requirement. Symptoms returned due to a L3 DRG lead fracture with an attempted revision. However, postsurgical complications developed: neuroforaminal scarring, which precluded lead replacement and resulted in explantation. A PNS implant was pursued with reported 75% to 80% symptom relief, titration off all medications, and significant return of function.

Conclusions: This case highlights PNS in treating advanced CRPS either as the initial neurostimulator of choice in select populations or as an effective alternative in the event that DRG stimulation or spinal cord stimulation proves ineffective or unfeasible. Here, our patient illustrated favorable results with PNS vs DRG in her CRPS management allowing her to regain her ability to function independently of constant pain and opioids.

Key words: Complex regional pain syndrome, dorsal root ganglion stimulation, peripheral nerve stimulation, case report

BACKGROUND

Complex regional pain syndrome (CRPS) is a chronic progressive neuropathic condition that generally presents following trauma, surgical procedures, or develop spontaneously (1). It typically effects the limbs and can become debilitating to the afflicted area (1,2). CRPS is diagnosed utilizing the Budapest Criteria or International Association for the Study of Pain (IASP) Criteria (3). The Budapest Criteria include continuing pain disproportionate to any inciting event and at least 1 symptom in 3 out of 4 categories. The 4 categories are sensory (i.e., hyperesthesia, allodynia, hyperalgesia), vasomotor, sudomotor/edema, and motor/trophic changes (1-4). The IASP Criteria for CRPS include a noxious event or cause for immobility, continuing pain, allodynia, or hyperalgesia that is disproportionate to the event, as

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well as edema and/or sudomotor changes (1,3,4). CRPS is confirmed when all other diagnosis are excluded (1,3,4). CRPS is also designated into 2 categories, CRPS Type I (formerly known as reflex sympathetic dystrophy) and CRPS Type II (formerly known as causalgia). Type I occurs when there isn't a specific nerve insult identified and Type II is designated when a specific nerve injury occurred (1,5).

In the United States, a study, published in 2010, estimated between 150,000 and 250,000 people suffering with CRPS (6). A 5-year study in patients with CRPS of the upper extremity indicated that 26% had to change their jobs and nearly 30% had to refrain from work for more than a year (1,7). Clinical recommendations are to pursue early, multifactorial treatment modalities, such as physical therapy, psychotherapy, along with medications (1). If conservative treatment becomes insufficient, interventional treatments, such as dorsal root ganglion (DRG) stimulation and peripheral nerve stimulation (PNS), have been proven effective measures in alleviating the condition (7-9). We present the case of a 44-year-old woman who underwent multiple knee surgeries originally for osteoarthritis that resulted in CRPS Type II of her right knee. She was initially and successfully treated with DRG stimulation, but postsurgical complications required the system to be explanted and replaced with PNS as an alternative. Following the PNS implantation, the patient reported 80% significant improvement of her CRPS symptoms with a regain in function. This case report aims to highlight the use of PNS as an effective treatment for CRPS when prior interventions may be unfeasible.

CASE REPORT

A 44-year-old woman with a history of right total knee arthroplasty (TKA), in March 2019, was initially examined at the pain clinic, in April 2019, for a preoperative evaluation for a planned revision of right TKA. Her past medical history was significant for right knee osteoarthritis and arthrofibrosis status post TKA. After the procedure, in August 2019, the patient subsequently developed CRPS of her right lower extremity and primarily around her right knee during her postoperative recovery, with a diagnosis made based on the Budapest Criteria. Initial symptoms included consistent pain that was described as sharp, burning, and electric with hyperalgesia. Her pain was rated to be a constant 9-10/10 and aggravated by movement or palpation. Eventually the appearance of flushed skin, temperature fluctuations, and sudomotor dysfunctions developed, which ultimately progressed to hyperalgesia, allodynia, and difficulty with ambulation due to pain. An early and multifaceted treatment approach was pursued, which included lumbar sympathetic blocks, epidural steroid injections, various medications, such as scheduled oxycodone, hydrocodone, tramadol, and lumbar L3/L4 DRG stimulation lead placements in 2020 (Fig. 1). Following the intervention, the patient reported 50% improvement in her symptoms. To further enhance her treatment, a genicular nerve block and genicular radiofrequency ablation were performed in 2021. All together, these additional interventions provided drastic improvement that enabled her to be titrated off all opioid medications. With improved range of motion and pain control, the patient was able to ambulate for over an hour without symptoms. She no longer experienced pain at rest or sudomotor dysfunction. However, a month following, the patient reported a gradual return of persistent pain and hyperalgesia. It was found through lumbar x-ray that the L3 DRG lead had fractured. An attempt was made to revise the DRG leads, but due to neural foramen scar tissue precluding proper placement as evident by high impedances among all 4 contacts, the leads were not able to be replaced and the system was subsequently explanted. As an alternative to DRG stimulation and a search for improved pain control to avoid opioid analgesics, as there was inadequate pain control with the L4 lead alone, a PNS trial was pursued in February 2022. The trial offered a reported even greater 75% to 80% improvement in pain (no pain at rest, pain rated 3/10 with prolonged movement) and reduction specifically in these symptoms when compared to DRG stimulation. During the trial, the patient no longer required any pain medications and had the greatest return in function to date. Due to the significant effectiveness of the PNS trial, a permanent PNS (Nalu Medical, Inc., Carlsbad, CA) was implanted in March 2022 (Fig. 2). On follow-up, the patient remains satisfied with her results, with the greatest improvement to her baseline function prior to the development of CRPS. This case illustrates the successful use of PNS in treatment of CRPS where other effective "last-line treatments" may have been proved ineffective or failed.

DISCUSSION

CRPS involves multiple pathophysiologic pathways and can be resistant to conventional treatment and difficult to manage. It may initially present as continuing

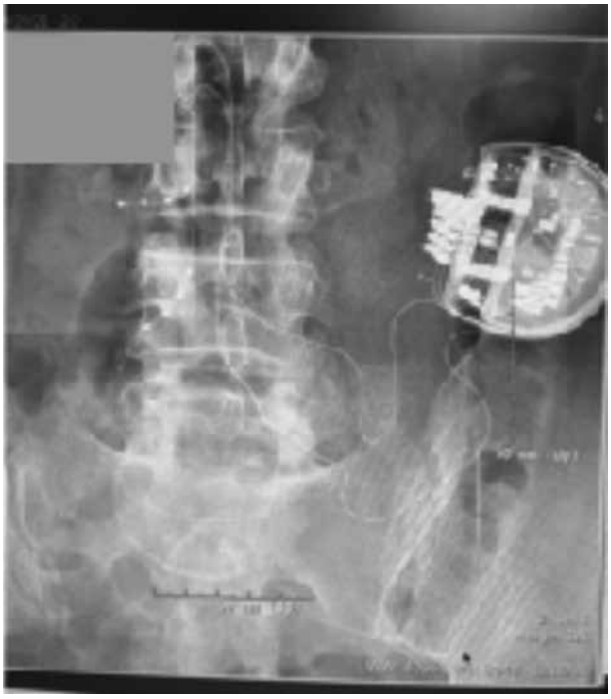


Fig. 1. Posterior lumbar x-ray. DRG stimulation lead placements L3 and L4 with battery pack.
DRG, dorsal root ganglion.

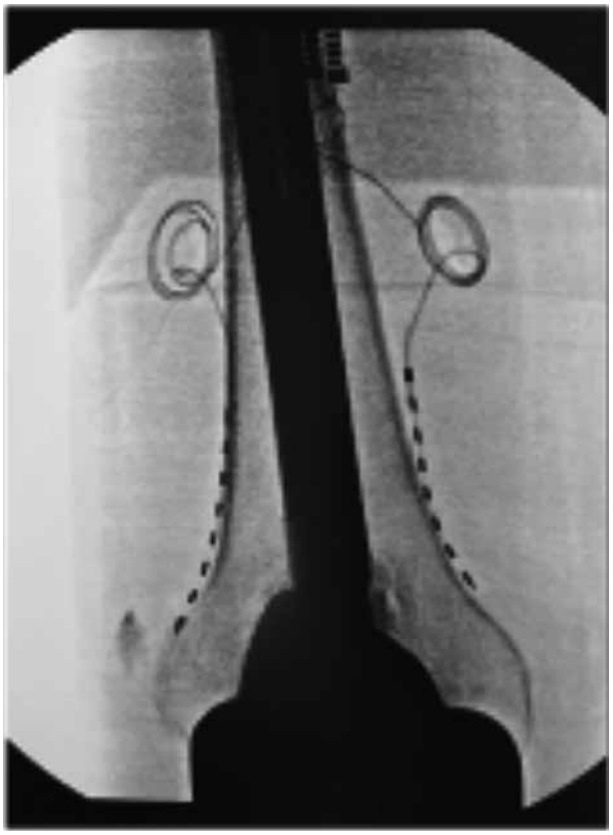
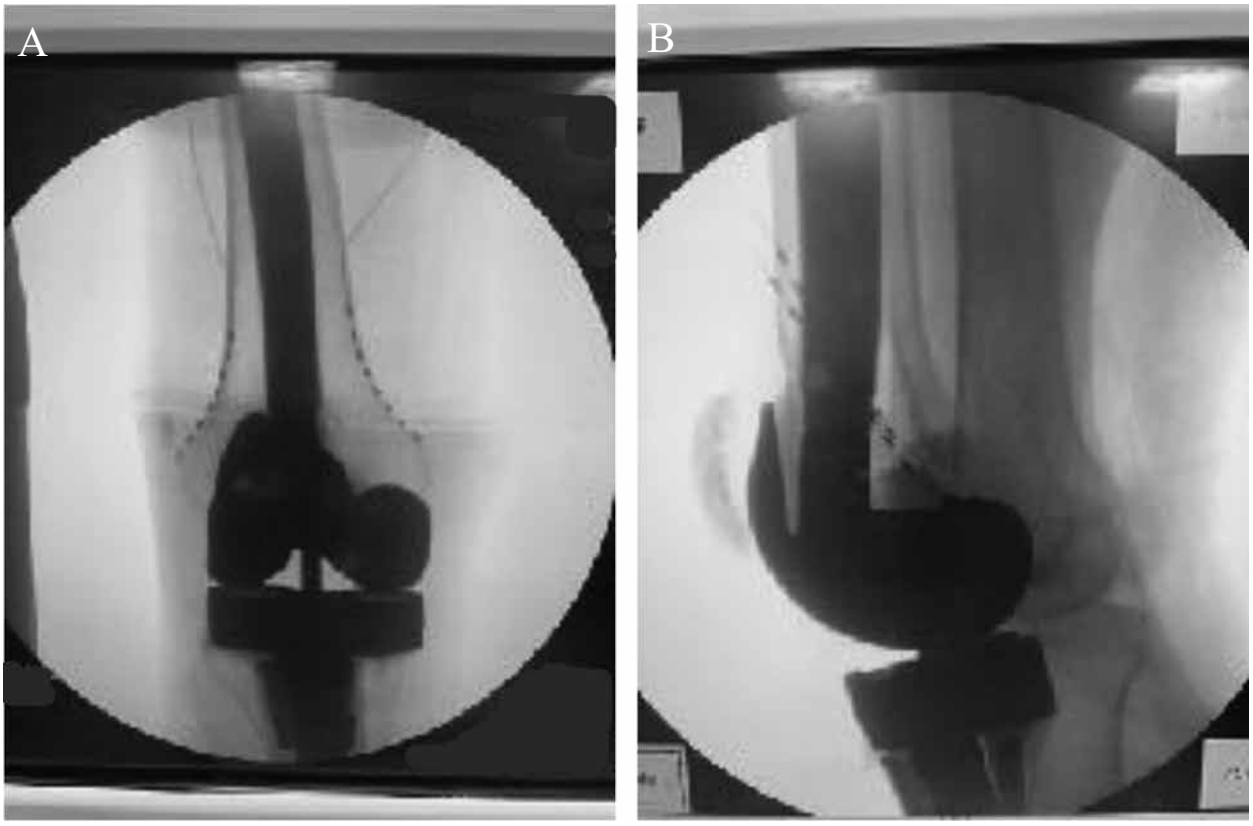


Fig. 2. Permanent NaluTM PNS lead placement.
PNS, peripheral nerve stimulation.

pain after direct insult to nerves or after a disproportionate noxious event, such as a sprained joint (1). It is believed to involve multifactorial pathways, including both peripheral and central nervous system involvement (10,11). Symptoms of CRPS include sensitization, inflammation, altered sympathetic and catecholaminergic function, altered somatosensory representation, genetics, and psychophysiological interactions (1,6). One theory for the development of CRPS suggests marked up-regulation of α1-adrenoceptors in the injured extremity (1). These newly expressed α1-receptors proliferate along skin, muscle, and nerve tissue. They then augment depolarization in nerve and muscle tissue, resulting in an amplification effect of any stimuli (1). CRPS is best approached with early multimodal treatment (1). If conservative management fails, neurostimulation interventions, such as PNS, should be included in the treatment algorithm. The use of a PNS device is based on the gate control theory that stimulation of large afferent nerve fibers can "gate" or limit the transmission of painful nociceptive stimuli (1,11). Strege et al (13) utilizing PNS illustrated 70% to 75% "good-excellent results" with the elimination of narcotic use in the same number of patients being treated for chronic pain. Mobbs et al (12) found that the most dramatic success with PNS occurred in patients with peripheral nerve trauma. As in our case, the patient likely developed CRPS from the recurrent surgical revisions.

Although other neurostimulator devices, such as DRG stimulation and spinal cord stimulators, exist as safe and effective treatments for CRPS, PNS provides another feasible alternative (9). We chose to pursue genicular vs saphenous PNS due to the patient's symptoms being exacerbated around her knee and to cover the area on both the medial and lateral aspect of the genicular nerves (Figs. 3). The genicular nerve innervates 4 quadrants of the knee: superolateral, superomedial, inferolateral, and inferomedial (14), in contrast to the saphenous nerve innervating the medial aspect of the leg down to the ankle and foot; thus, potentially missing the primary afflicted area, the patient's knee, and the lateral lower extremity, which was also affected.

Furthermore, in the United States, it is estimated that there may have between 150,000 and 250,000 people suffering with CRPS (6). A separate retrospective cohort



Figs. 2. Anterior (A) and lateral (B) right knee x-rays. PNS trial lead placements targeting right knee lateral and medial genicular nerves.
PNS, peripheral nerve stimulation.

study, from 1996-2005, estimated an incidence of 26 per 100,000 patients per year (6,15). In addition to the physical and emotional challenges the patient endures, the estimated median total cumulative cost 8 years after CRPS diagnosis is $55,063 for treatment (16). Therefore, PNS may prove to be a cost-effective treatment for CRPS by reducing medications and the need for other alternative therapies. In our case, PNS was a success for our patient. It improved the patient's quality of life by controlling pain symptoms and subsequently reduced the need for narcotics.

As this case report illustrates when conservative management fails and complications arise with DRG stimulation implantation, such as fractured leads, lead migrations, and revision attempts fail, PNS is an effective alternative.

CONCLUSIONS

This case highlights the value of PNS in treating CRPS either as the initial neurostimulator of choice in select populations or as an effective alternative in the event that DRG stimulation or spinal cord stimulation proves ineffective or unfeasible. In this case, the patient illustrated favorable results with PNS vs DRG in her CRPS management allowing her to regain her ability to function independently of constant pain and opioids.

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