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CASE REPORT

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Combined use of peripheral nerve stimulation and dorsal root ganglion stimulation for refractory complex regional pain syndrome type I to avoid amputation: A case report

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Abstract

We describe a case of left foot and ankle complex regional pain syndrome type 1 that necessitated a novel combination of a functioning dorsal root ganglion stimulation and peripheral nerve stimulation. This approach optimized pain relief, functional improvement, and avoided amputation.

KEYWORDS

complex regional pain syndrome, dorsal root ganglion stimulation, neuromodulation, peripheral nerve stimulation

1 | INTRODUCTION

The diagnosis of complex regional pain syndrome (CRPS) is made using the Budapest criteria which takes into account both signs on physical examination, and symptoms that the patient reports across four categories- sensory, vasomotor, sudomotor, and motor.[7] This was recently updated in Valencia with changes made to the diagnostic parenting, CRPS subtypes, and diagnostic procedure.[6] The incidence of CRPS is estimated at 26.2 per 100, 000 with a 3:1 female to male distribution.[3] The initial randomized control trial of neuromodulation for this disease showed superiority of dorsal column stimulation when compared to physical therapy alone, however there was no functional improvement in either group.[10] Currently, there are three primary neural targets for stimulation including the dorsal column, dorsal root ganglion (DRG), and peripheral nerves (PNS). Other less commonly utilized targets include the brachial plexus and nerve roots. Deciding on which neural target for stimulation takes into consideration the location of pain, MRI labeling, charge burden of external or internal pulse generator, spinal hardware, medical comorbidities, and patient lifestyle. Dorsal column stimulation offers the advantage of providing a larger field of stimulation, has the most comprehensive MRI labeling and numerous options for energy delivery. Peripheral nerve and dorsal root ganglion stimulation (DRG-s) are effective treatment modalities for focal neuropathic pain including complex regional pain syndrome (CRPS) that is limited to one or two dermatomes.[2,4,15] While a reduction in pain of fifty percent or greater is often deemed a satisfactory response in the treatment of

chronic pain, we describe a case were the patient sought amputation of her limb in the hopes a prosthetic extremity would provide improved function. Despite the risk of post amputation pain, there are patients that seek amputation for CRPS that is refractory to treatment.[1,9,12] We proceeded with peripheral nerve stimulation (PNS) in addition to her DRGs system in effort to avoid her upcoming amputation.

2 | MATERIALS AND METHODS

Advocate Aurora Health Institutional Review Board (IRB) deemed this study non-human subject research and waived the need for consent. Patient authorization was obtained. Declaration of Helsinki principles were followed. Patient outcomes, and medical history data was derived from Electronic Medical Records.

A 52-year-old woman presented to our clinic with a medical history of chronic left foot and ankle pain. This pain started following a fracture of left distal fibula. She had undergone an open reduction and internal fixation and had been placed in a controlled ankle motion boot on and off over the course of 1 year. Prior to presenting to our clinic, she had a diagnosis of CRPS type 1 and had failed to improve with greater than 12 weeks of physical therapy, pain mirror box therapy, pain psychology, and several lumbar sympathetic blocks done at outside institutions. She was taking duloxetine 30 mg daily, pregabalin 200 mg three times a day, oxycodone/acetaminophen 5 mg every 6 h as needed. After discussing her options, the patient was successfully trialed and implanted with a DRG spinal cord stimulator with leads at L4, L5, S1 that provided approximately 50% pain relief for 2 years (Figure 1). Her residual pain was still limiting function and affecting her quality of life. She sought evaluation from orthopedics for an ankle arthroplasty but advised that is not possible and a below the knee amputation with eventual prosthesis would be her only option. Understanding the possibility of post-amputation pain and stump pain, she scheduled the below the knee amputation. In an effort to avoid this, we performed sciatic and saphenous nerve blocks as a diagnostic tool to identify the peripheral nerve dermatome which resulted in significant pain relief for the next 2 days. Two temporary PNS leads targeting the sciatic and saphenous nerves were implanted and provided 100% pain relief for the next 5 days until the sciatic lead fractured and most of her pain returned. The residual sciatic lead and saphenous lead were removed. The patient went on to a permanent PNS device, (StimRouter™, Bioventus Inc.) (Figure 2). The patient's progress was followed for the next 120 days.

3 | RESULTS

Patient reported pain intensity has improved from 7/10 to 2/10 NRS over 4 months while pain interference scores have reduced from 19 to 9 as measured by PROMIS-29 v2.1 (Figure 3).

Compared to baseline, the patient has also experienced increased physical function, and her ability to participate in social roles and activities increased over 4 months. Her use of opioid medication diminished by 75% as she is now taking oxycodone/acetaminophen 0.5 tab twice daily as needed. Allodynia has resolved, she is able to wear shoes, ambulate short distances without a cane and is considering re-entering the workforce.

T-scores from PROMIS-29 v2.1 are also reported as shown in Figure 4 where 50 represents the US general population. It is clear that all six categories of PROMIS-29 have improved. The patient has started to feel less depressed, anxious, fatigued, and her sleep quality has improved.

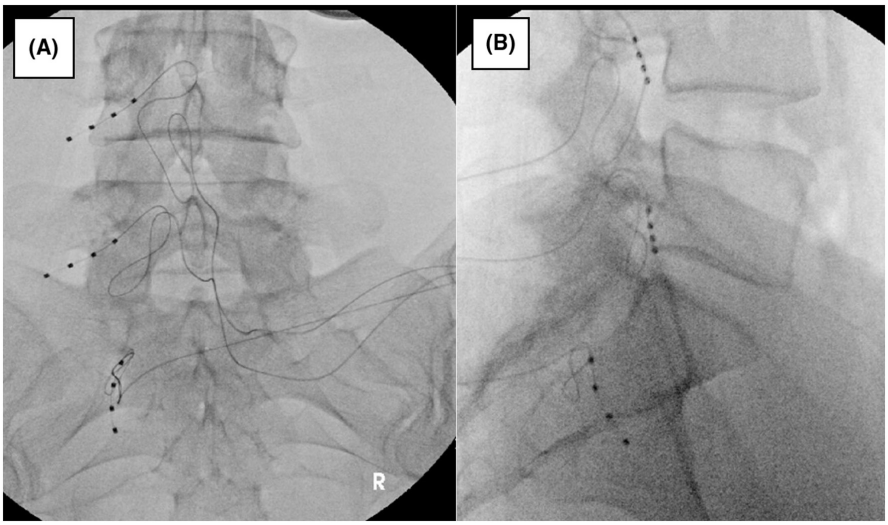

FIGURE 1 A/P view (A) and lateral view (B) lumbar spine x-ray showing DRG lead placements at L4, L5, S1.

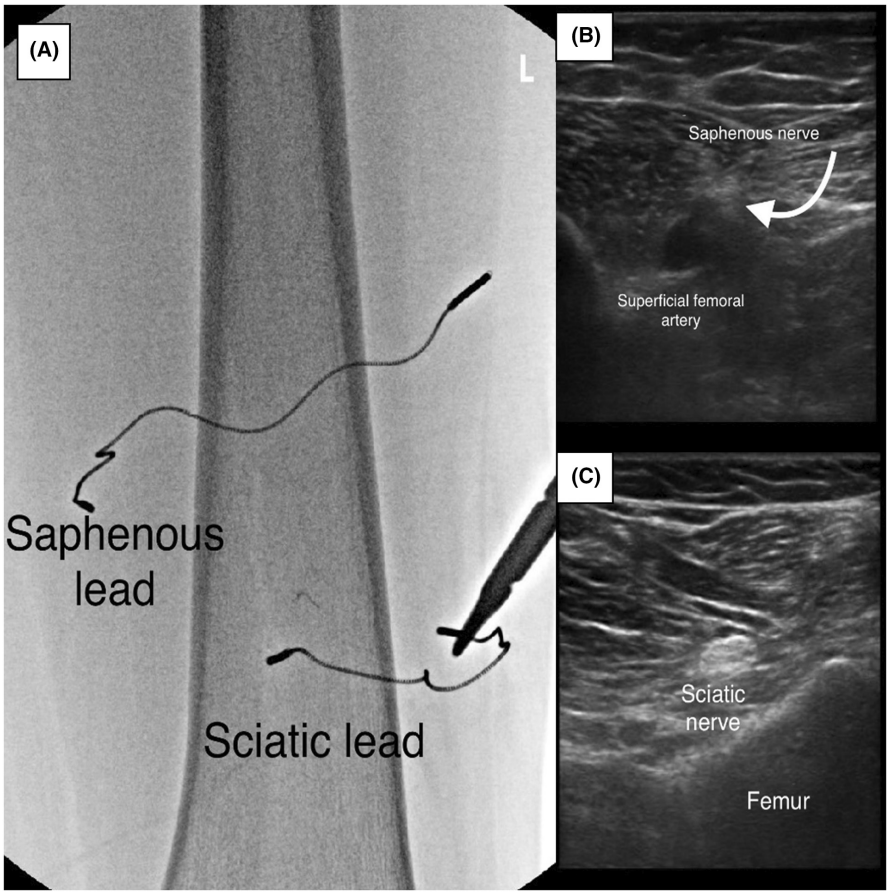

FIGURE 2 X-ray imaging of permanent StimRouter™ lead placements (A) and ultrasound-guided imaging of saphenous nerve (B), and sciatic nerve (C).

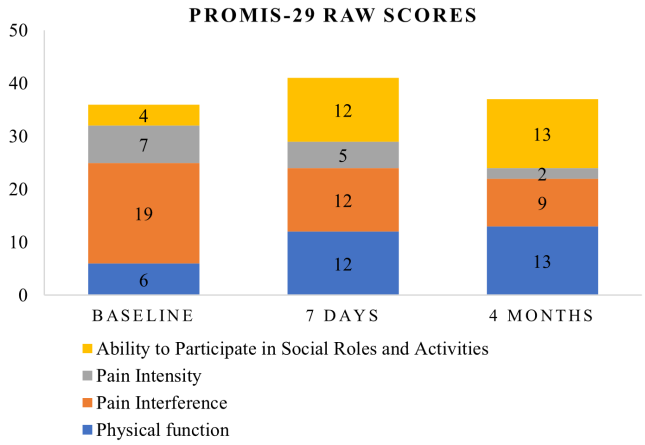

FIGURE 3 Treatment outcomes in pain intensity, pain interference, physical function, and ability to participate in social roles and activities over 4 months as measured through PROMIS-29 (higher score = more) (range 4–20).

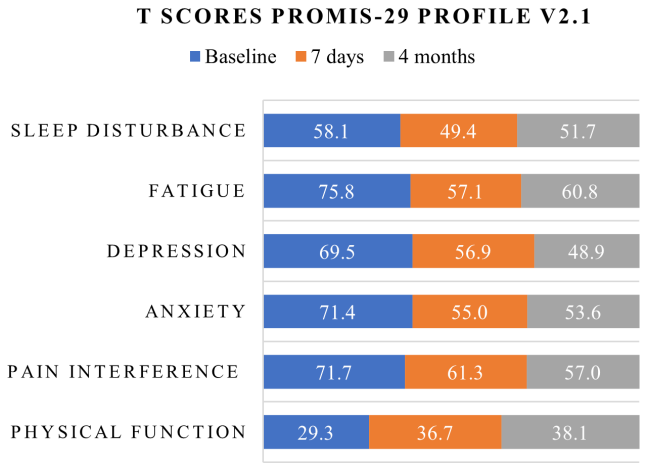

FIGURE 4 Change in T-scores from PROMIS-29 in sleep disturbance, fatigue, depression, anxiety, pain interference, and physical function over 4 months (higher = more).

4 | DISCUSSION

Patients with refractory CRPS may seek amputation as a form of treatment. This case demonstrates the combined efficacy of PNS in conjunction with DRG-s, which allowed the patient to avoid a life-altering surgery and have sustained functional improvement. At the core of treatment for CRPS is physical therapy with a focus on desensitization and strengthening, mirror therapy, neuropathic medications, sympathetic blockade, and neuromodulation. Which neural structure to target is a complex decision taking into consideration the body of evidence behind a therapy, patient lifestyle, medical comorbidities, spinal anatomy, and ability to charge an external pulse generator.

Dorsal column spinal cord and dorsal root ganglion stimulation are both efficacious treatment modalities for CRPS.[4,10] A prospective multicenter randomized control trial comparing the two demonstrated superior efficacy, less postural variation in paresthesia, and reduced extraneous stimulation of non-painful areas when using DRGs.[4] While our patient had reported approximately 50% pain relief for 2 years after DRGs, she did not have improvement with function and continued to have allodynia that limited her footwear options. Given the disabling nature of the pain, the patient considered and decided to pursue amputation. For treatment resistant and long-standing CRPS, some patients seek amputation as a treatment option. While amputation represents an extreme option, the very few reported case reports and cases series have shown improvements in consumption of analgesics, the quality of sleep and the ability to function, as well as improvement in overall pain scores, which were not substantial. Nonetheless, amputation may be associated with recurrent CRPS in the stump or phantom limb pain.[1]

Prior to her amputation, the patient was scheduled for sciatic and saphenous nerve blocks, which were used as a mapping tool prior to placing temporary PNS leads. While the use of nerve blocks does not have a correlation with success of neurostimulation, it may be helpful in assessing anatomy and identifying a dermatome. At 4 months post implant, the patient's pain intensity improved from 7/10 to 2/10 NRS and pain interference scores have reduced from 19 to 9 as measured by PROMIS-29 v2.1. Case series data have shown improvements in CRPS symptoms in patients with pain limited to one major nerve.[8,13] Another study targeted the brachial plexus for upper extremity CRPS with 57.4% improvement in pain on the visual analog scale at 12 months.[5]

PNS has been available for over 50 years, but adoption was limited due to open invasive placement technique or large variation in efficacy with anatomic, fluoroscopic, or nerve stimulator paresthesia based percutaneous placement. In addition, the use of off label spinal cord stimulator leads resulted in high incidence of migration, dislodgement, and lead fractures. With ultrasound-guided placement neural targets are easily identified, improvements in percutaneous lead delivery, specialized lead design to be used in the periphery, and extensive options in energy delivery via both internal and external pulse generators have led to a resurgence in utilization. While gate control theory continues to be the leading theory to explain the analgesic effect produced by PNS, numerous other theories exist. These include electrical stimulation of afferent nerve fibers changing the firing pattern of Aδ fibers, decreased hyperexcitability and long-term potentiation of dorsal horn neurons, depletion of excitatory amino acids, and increased release of inhibitory neurotransmitters.[11]

This case aims to highlight the efficacy of PNS in refractory CRPS but also serves as a reminder that 50% pain relief is often not enough. When patients struggle with functional metrics despite neuromodulation of a single target, another target may be considered. The use of more than one neuromodulation therapy in a patient is not novel, as there have been many case reports discussing use of both SCS and DRGs. The use of PNS to salvage malfunctioning DRG has also been described.[14] To our knowledge, this is the first case to describe the addition of PNS to a functioning DRGs therapy to avoid amputation. Our patient had greater than 50% pain relief for 2 years with her DRGs, but unfortunately her residual pain led to more functional disability. The addition of PNS in conjunction with her DRGs, has allowed her to not only have more significant pain improvement, but also have increased and sustained functionality. This may be explained by the summative effect of the different mechanisms that PNS and DRGs work on CRPS. It is unknown if the patient would have had a favorable outcome had she opted for PNS instead of DRGs from the start or if the relief she is experiencing today is a function of combined therapy. A prospective study comparing PNS to DRG stimulation for the treatment of CRPS would be helpful in answering many of these questions.

5 | CONCLUSION

This case discusses a 52-year-old female with CRPS type 1 in the lower limb who was successfully treated with DRGs providing her 50% reduction in pain, without improvement in allodynia and function. She sought amputation as a possible treatment and in order to avoid this life altering surgery, we implanted a sciatic and saphenous peripheral nerve stimulator. At 4 months, she continues to report improvement in pain intensity, pain interference and physical function. To our knowledge, this is the first report of PNS in addition to DRGs for the treatment of refractory CRPS in order to avoid amputation in the literature. Large studies are needed to study the safety and efficacy of this dual approach.

AUTHOR CONTRIBUTIONS

Mansoor M. Aman: Conceptualization; data curation; investigation; methodology; project administration; supervision; writing – original draft; writing – review and editing. **Yussr M. Ibrahim:** Investigation; writing – original draft; writing – review and editing. **Merve Buluk Figueira:** Data curation; investigation; writing – original draft; writing – review and editing. **Jessica M. Werhand:** Investigation; writing – original draft; writing – review and editing.

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FUNDING INFORMATION
None.

CONFLICT OF INTEREST STATEMENT
MMA is a consultant for Abbott. YMI, MBF, and JMW report no conflicts.

DATA AVAILABILITY STATEMENT
Data from this study, per Advocate Aurora Health IRB regulations, cannot be shared with external organizations.

ETHICS STATEMENT
Advocate Aurora Health Institutional Review Board (IRB) deemed this study non-human subject research and waived the need for consent. Patient authorization was obtained. Declaration of Helsinki principles were followed. Patient outcomes and medical history data was derived from Electronic Medical Records.

CONSENT
Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

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REFERENCES
1. Ayyaswamy B, Saeed B, Anand A, Chan L, Shetty V. Quality of life after amputation in patients with advanced complex regional pain syndrome: a systematic review. *EFORT Open Rev*. 2019;4(9):533-540.
2. Chmiela MA, Hendrickson M, Hale J, et al. Direct peripheral nerve stimulation for the treatment of complex regional pain syndrome: a 30-year review. *Neuromodulation*. 2021;24(6):971-982.
3. de Mos M, de Bruijn AG, Huygen FJ, Dieleman JP, Stricker BH, Sturkenboom MC. The incidence of complex regional pain syndrome: a population-based study. *Pain*. 2007;129(1–2):12-20.
4. Deer TR, Levy RM, Kramer J, et al. Dorsal root ganglion stimulation yielded higher treatment success rate for complex regional pain syndrome and causalgia at 3 and 12 months: a randomized comparative trial. *Pain*. 2017;158(4):669-681.
5. Frederico TN, da Silva FT. Peripheral nerve stimulation of the brachial plexus for chronic refractory CRPS pain of the upper limb: description of a new technique and case series. *Pain Med*. 2020;21(Suppl 1):S18-S26.
6. Goebel A, Birklein F, Brunner F, et al. The Valencia consensus-based adaptation of the IASP complex regional pain syndrome diagnostic criteria. *Pain*. 2021;162(9):2346-2348.
7. Harden NR, Bruehl S, Perez R, et al. Validation of proposed diagnostic criteria (the "Budapest criteria") for complex regional pain syndrome. *Pain*. 2010;150(2):268-274.
8. Hassenbusch SJ, Stanton-Hicks M, Schoppa D, Walsh JG, Covington EC. Long-term results of peripheral nerve stimulation for reflex sympathetic dystrophy. *J Neurosurg*. 1996;84(3):415-423.
9. Kashy BK, Abd-Elsayed AA, Farag E, Yared M, Vakili R, Esa WA. Amputation as an unusual treatment for therapy-resistant complex regional pain syndrome, type 1. *Ochsner J*. 2015;15(4):441-442.
10. Kemler MA, Barendse GA, van Kleef M, et al. Spinal cord stimulation in patients with chronic reflex sympathetic dystrophy. *N Engl J Med*. 2000;343(9):618-624.
11. Lin T, Gargya A, Singh H, Sivanesan E, Gulati A. Mechanism of peripheral nerve stimulation in chronic pain. *Pain Med*. 2020;21(Suppl 1):S6-S12.
12. Midbari A, Suzan E, Adler T, et al. Amputation in patients with complex regional pain syndrome: a comparative study between amputees and non-amputees with intractable disease. *Bone Joint J*. 2016;98-B(4):548-554.
13. Sokal P, Harat M, Zielinski P, Kieronska S. Tibial nerve stimulation with a miniature, wireless stimulator in chronic peripheral neuropathic pain. *J Pain Res*. 2017;10:613-619.
14. Music S, Suvar T. Treatment of complex regional pain syndrome of the knee with peripheral nerve stimulation after failed dorsal root ganglion stimulation. *Pain Medicine Case Reports*. 2022;6(7):261-265.
15. Xu J, Sun Z, Wu J, et al. Peripheral nerve stimulation in pain management: a systematic review. *Pain Physician*. 2021;24(2):E131-E152.

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