LATIN Neurosurgery

Case Report

Spinal cord stimulation in neuropathic pain following lower limb amputation

Estimulación de la médula espinal en el dolor neuropático tras la amputación de miembros inferiores

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ABSTRACT

Background: *Phantom limb pain (PLP) is a chronic neuropathy that affects up to 90% of amputees and is often refractory to conventional treatments, including opioids. When traditional therapies fail to provide adequate relief, surgical interventions, such as spinal cord stimulation (SCS), have shown promising results. This case report presents a 28-year-old woman who experienced chronic PLP following an above-the-knee amputation of her right leg three years ago because of a traumatic injury. Despite prolonged opioid treatment, the patient's pain remained unresolved, with a severity of 10/10 on the Visual Analogue Scale (VAS). After successful treatment using a dual-channel dorsal column stimulator, a permanent Medtronic® Prime Advanced SCS system was implanted. The patient reported significant pain relief (the VAS score was reduced to 1/10) and 90% improvement in quality of life. This case underscores the potential of SCS as an effective, minimally invasive, and opioid-sparing therapy for phantom limb pain.* **Objectives:** *To characterize the efficacy and safety of spinal cord stimulation (SCS) compared with opioid therapy for managing phantom limb pain (PLP), this study examined its impact on pain reduction, functional outcomes, and quality of life (QOL) improvements. By analyzing these factors, it explores the potential of SCS as a viable long-term solution for PLP, offering an alternative to conventional pharmacological approaches.* **Design**: *This study combined a systematic literature review with a case report.* **Results**: *The patient reported a significant reduction in pain intensity, with VAS scores decreasing from 10/10 to 1/10. She noted substantial improvements in her ability to perform daily activities, including work tasks and mobility, along with a marked enhancement in her mood and sleep quality. Additionally, her reliance on opioids diminished, and she eventually discontinued their use entirely, given that the spinal cord stimulation alone provided sufficient pain relief. She described a 90% improvement in her overall quality of life, attributing this to the sustained pain relief provided by SCS.* **Conclusion:** *This study highlights spinal cord stimulation (SCS) as an effective, minimally invasive alternative to opioid therapy for phantom limb pain (PLP). The patient showed significant pain reduction, improved quality of life, and ceased opioid use. However, the results are not generalizable, and concerns remain regarding long-term efficacy, cost, and limited availability. Further research is needed to validate these findings and improve treatment access. SCS appears to be a promising option for managing PLP and other chronic neuropathic pain conditions.*

Keywords: *Phantom Limb Pain (PLP); phantom limb; pain management; Spinal Cord Stimulation (SCS); opioids; lower extremity amputation; chronic pain; neuropathic; amputees.*

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RESUMEN

Antecedentes: *El dolor del miembro fantasma (DMF) es una neuropatía crónica que afecta hasta al 90% de los amputados y, a menudo, es refractario a los tratamientos convencionales, incluidos los opioides. Cuando las terapias tradicionales no logran proporcionar alivio adecuado, intervenciones quirúrgicas como la estimulación de la médula espinal (EME) han mostrado resultados prometedores. Este informe de caso presenta a una mujer de 28 años que experimentó DMF crónico después de una amputación transfemoral de su pierna derecha hace tres años debido a una lesión traumática. A pesar de un tratamiento prolongado con opioides, el dolor de la paciente persistió con una intensidad de 10/10 en la Escala Visual Analógica (EVA). Tras un tratamiento exitoso utilizando un estimulador de columna dorsal de doble canal, se implantó un sistema permanente de EME Medtronic® Prime Advanced. La paciente reportó un alivio significativo del dolor (reducción de la puntuación EVA a 1/10) y una mejora del 90% en su calidad de vida. Este caso destaca el potencial de la EME como una terapia eficaz, mínimamente invasiva y que reduce el uso de opioides para el dolor del miembro fantasma.* **Objetivos:** *Caracterizar la eficacia y seguridad de la estimulación de la médula espinal (EME) en comparación con la terapia con opioides para el manejo del dolor del miembro fantasma (DMF). Este estudio examinó su impacto en la reducción del dolor, los resultados funcionales y las mejoras en la calidad de vida (CdV). Al analizar estos factores, explora el potencial de la EME como una solución viable a largo plazo para el DMF, ofreciendo una alternativa a los enfoques farmacológicos convencionales.* **Diseño:** *Este estudio combinó una revisión sistemática de la literatura con un informe de caso.* **Resultados:** *La paciente reportó una reducción significativa en la intensidad del dolor, con puntuaciones EVA que disminuyeron de 10/10 a 1/10. Señaló mejoras sustanciales en su capacidad para realizar actividades diarias, incluidas tareas laborales y movilidad, junto con una notable mejora en su estado de ánimo y calidad del sueño. Además, su dependencia de los opioides disminuyó y finalmente dejó de utilizarlos, dado que la estimulación de la médula espinal proporcionó un alivio suficiente del dolor. Describió una mejora del 90% en su calidad de vida general, atribuyéndolo al alivio del dolor sostenido proporcionado por la EME.* **Conclusión:** *Este estudio destaca la estimulación de la médula espinal (EME) como una alternativa eficaz y mínimamente invasiva a la terapia con opioides para el dolor del miembro fantasma (DMF). La paciente mostró una reducción significativa del dolor, mejoró su calidad de vida y dejó de usar opioides. Sin embargo, los resultados no son generalizables, y persisten preocupaciones sobre la eficacia a largo plazo, los costos y la disponibilidad limitada. Se necesita más investigación para validar estos hallazgos y mejorar el acceso al tratamiento. La EME parece ser una opción prometedora para el manejo del DMF y otras condiciones de dolor neuropático crónico.*

Palabras clave: *Dolor del Miembro Fantasma (DMF); miembro fantasma; manejo del dolor; Estimulación de la Médula Espinal (EME); opioides; amputación de extremidad inferior; dolor crónico; neuropático; amputados.*

1 INTRODUCTION

Phantom limb pain (PLP) is a chronic neuropathic condition that affects most amputees, often resistant to conventional treatments, including opioids. This study presents the case of a 28-year-old patient with refractory PLP following a transfemoral amputation, whose treatment with spinal cord stimulation (SCS) resulted in significant pain relief (VAS score reduction from 10/10 to 1/10) and 90%improvement in quality of life. These findings highlight SCS as an effective and minimally invasive alternative for managing PLP, reducing opioid[1] dependence, and enhancing patient functionality.

2 PHANTOM LIMB PAIN

Phantom Limb Pain (PLP) is a chronic neuropathic pain syndrome characterized by the perception of painful sensations in the area of the body that has been amputated. It affects approximately 42%–90% of amputees and is often described as the sensations of tingling, throbbing, stabbing, or "pins and needles". These sensations are among the most commonly reported types of pain and are thought to arise from complex interactions involving peripheral nerve injury, maladaptive cortical reorganization, and central sensitization. Conventional management strategies for PLP include pharmacological therapies, such as anticonvulsants (e.g.,

gabapentin and pregabalin), antidepressants, local anesthesia, NMDA receptor antagonists, and opioids. However, these approaches often yield variable and limited efficacy, with many patients experiencing inadequate pain relief or intolerable side effects, particularly with long-term opioid use. Furthermore, a 2016 Cochrane review highlighted the lack of high-quality evidence supporting the use of pharmacological treatments for PLP, underscoring the need for further investigation into alternative therapeutic approaches to improve patient outcomes[2,3].

3 MAJOR TREATMENTS

Although opioid treatment for phantom limb pain may provide temporary relief, it is important to consider the potential side effects, particularly with long-term use. One concern is tolerance, in which the body becomes less responsive to opioids overtime, necessitating higher doses for the same effect. This can lead to dependence and addiction because the body may rely on the medication to avoid withdrawal symptoms, and some individuals may misuse the drug. Opioids may cause sedation and cognitive impairment, leading to drowsiness, confusion, and difficulty in concentrating, and may hinder daily tasks such as driving and working. Constipation is another common side effect that can become chronic and cause discomfort and reduced appetite, leading to additional health complications, such as bloating and bowel obstruction.

A more serious concern is respiratory depression, where breathing becomes slower and shallower, posing significant risks, especially at higher doses or when combined with other central nervous system (CNS) depressants, such as alcohol or benzodiazepines. Long-term opioid use can also result in mood changes, including symptoms of depression or anxiety, which can further complicate the management of pain. Additionally, opioid-induced hyperalgesia may develop, whereby prolonged opioid use paradoxically increases pain sensitivity, potentially worsening phantom limb pain and reducing the effectiveness of the medication. Chronic use of opioids can also impair immune function, making the body more vulnerable to infections. Given these potential challenges, opioids are generally not considered a long-term solution for phantom limb pain, and alternative treatment options are often explored to manage pain in a safer and more effective manner, particularly spinal cord stimulation[1,2].

4 SPINAL CORD STIMULATION

Spinal cord stimulation (SCS) has proven to be a promising and valuable treatment option for chronic neuropathic pain, including phantom limb pain, particularly for individuals who do not experience sufficient relief with conventional therapies[4,5]. SCS delivers electrical pulses to the spinal cord via an implanted electrode array, modulating pain signals before they reach the brain[6], thereby reducing the perception of pain in the phantom limb. This neuromodulation technique is particularly effective in patients who experience chronic, intractable neuropathic pain following amputation. The procedure is generally performed using a minimally invasive approach, with the electrode array carefully positioned in the epidural space surrounding the spinal cord. In many cases, a temporary device is initially used during the trial period to evaluate treatment effectiveness. This allows patients to assess whether the stimulation significantly improves their pain relief and quality of life before making a commitment to a permanent implant.

5 METHODS

This case report describes a 28-year-old woman who experienced chronic PLP following an above-the-knee amputation of her right leg due to a bus accident four years prior (Figure 1 and Figure 2). Her pain, which was initially intermittent, became continuous and was described as “pins and needles”. At her first consultation, her pain was rated 10/10 on the Visual Analogue Scale (VAS), which significantly impaired her quality of life. Previous treatments included combined therapy with gabapentin (300 mg every 6 hours) and amitriptyline, duloxetine (300 mg once a day) during hospitalization, oral opioids, and various interventional procedures, none of which offered lasting relief.

After discussing treatment options, the patient underwent spinal cord stimulation (SCS). A dual-channel electrode array was placed in the thoracic epidural space using a minimally invasive technique, and the atrial device was activated. After successful pain relief during the trial period, a permanent SCS system (Medtronic® Prime Advanced) was implanted (Figure 3).

Figure 1. The patient is fitted with a prosthetic leg on the right side, following an above-knee amputation. The prosthesis features a modular design, including a mechanical knee joint to facilitate mobility and a durable foot component for stability. The patient is standing upright, demonstrating proper alignment of the prosthetic limb.

The parameters recorded after permanent electrode implantation were 1.2 mA, 90 PW, and 120 Hz. In subsequent consultations, only the mA value was adjusted. It initially increased to 2 mA, then to 3 mA, and subsequently to 3.5 mA, with these changes occurring over a 30-day period. At the last consultation, two months after the SCS operation, this value, which had been steadily increasing and decreasing, 2.4 mA.

6 DISCUSSION

This case highlights the potential of spinal cord stimulation as a safe alternative to opioid therapy for managing phantom limb pain. Unlike opioids, which carry risks of tolerance, dependence, and adverse effects, SCS provides long-term relief by modulating pain pathways. The patient's significant pain reduction and improved functional outcomes align with the existing literature reporting 70%–90% efficacy rates for SCS in patients with chronic neuropathic pain.

Although the results are promising, several limitations should be considered. First, this is a single case report, and findings may not be generalizable. Second, the long-term efficacy of this minimally invasive therapy can diminish overtime, due to factors, such as neural adaptation, necessitating further research into factors influencing sustained outcomes. Finally, access to spinal cord stimulation may be limited by cost and availability, highlighting the need for broader analysis and support for this treatment modality.

Figure 2. Radiographic evaluation of a patient who has undergone an above-knee amputation on the right side, fitted with a modular prosthetic limb. The X-ray highlights the skeletal structure of the pelvis and femur, longside the attached prosthetic components.

Figure 3. X-ray image depicts a frontal view of the thoracic and abdominal regions of the patient in a standing position. The image reveals the presence of a spinal cord stimulator implant, identifiable by the electrodes positioned along the spinal column and the connected pulse generator located in the lower abdominal region.

Bearing in mind the limitations of SCS, investigating strategies such as adjunctive therapies (e.g., combining SCS with pharmacological treatments or physical therapy)[7,8] could help to reduce costs, improve accessibility, and enhance long-term effectiveness.

7 CONCLUSION

This case underscores the potential of spinal cord stimulation (SCS) as a promising, minimally invasive, and effective alternative to opioid therapy for managing phantom limb pain (PLP). The significant reduction in pain intensity, improvement in quality of life, and discontinuation of opioid use observed in this patient demonstrate the therapeutic benefits of SCS. Furthermore, these outcomes align with existing literature, highlighting the efficacy of this therapy in managing chronic neuropathic pain conditions[4,5].

However, as a single case report, these findings are not generalizable and must be interpreted with caution. Long-term efficacy remains a concern due to factors, such as neural adaptation, and the high cost and limited availability of SCS pose barriers toits widespread adoption. Further research is essential to validate these findings, investigate patient-specific factors influencing sustained outcomes, and develop strategies to improve cost-effectiveness and accessibility.

Ultimately, spinal cord stimulation is a safe and effective option for patients with refractory PLP, offering significant improvements in pain management and quality of life while reducing reliance on pharmacotherapy[4,5]. With continued advancements and broader support, SCS can become a core element for treating phantom limb pain and other chronic neuropathic pain conditions.

REFERENCES

1. Al-Kaisy A, Van Buyten J-P, Carganillo R, et al. 10 kHz SCS therapy for chronic pain, effects on opioid usage: post hoc analysis of data from two prospective studies. Sci Rep. 2019;9(1):11441. http://doi.org/10.1038/s41598-019-47792-3. PMid:31391503.

2. Doshi TL, Dolomisiewicz E, Caterina MJ, et al. Postamputation pain: a multidisciplinary review of epidemiology, mechanisms, prevention, and treatment. Reg Anesth Pain Med. 2025;50(2):175-83. http://doi.org/10.1136/rapm-2024-105817. PMid:39909547.

3. Culp CJ, Abdi S. Current understanding of phantom pain and its treatment. Pain Physician. 2022;25(7):E941-57. PMid:36288580.

4. Galafassi GZ, Aguiar PHSP, Simm RF, et al. Neuromodulation for medically refractory neuropathic pain: spinal cord stimulation, deep brain stimulation, motor cortex stimulation, and posterior insula stimulation. World Neurosurg. 2021;146:246-60. http://doi.org/10.1016/j.wneu.2020.11.048. PMid:33217591.

5. Lazorthes Y, Siegfried J, Verdie JC, et al. Chronic spinal cord stimulation in the treatment of neurogenic pain: cooperative and retrospective study on 20 years of follow-up. Neurochirurgie. 1995;41(2):73-86. PMid:7630466.

6. Lazorthes Y, Verdié J-C, Sol J-C. Spinal cord stimulation for neuropathic pain. In: Cervero F, Jensen TS, editors. Handbook of clinical neurology. Amsterdam: Elsevier; 2007. p. 887-99. vol. 81. https://doi.org/10.1016/S0072-9752(06)80064-3.

7. Sued J, Sued S. ID: 341861 spinal cord stimulation therapy for the treatment of chronic phantom limb pain: a case report. Neuromodulation. 2024;27(7):S114. http://doi.org/10.1016/j.neurom.2024.06.221.

8. Hwang BY, Negoita S, Duy PQ, et al. Opioid use and spinal cord stimulation therapy: the long game. J Clin Neurosci. 2021;84:50-2. http://doi.org/10.1016/j.jocn.2020.12.004. PMid:33485599.

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