



COMPARISON OF SPINAL CORD NEUROMODULATION OUTCOMES FOR REFRACTORY CHRONIC PAIN IN PATIENTS WITH DIABETIC NEUROPATHY AND POSTHERPETIC NEURALGIA A TECHNICAL AND QUALITY OF LIFE ANALYSIS

Alana Moury Fernandes Leite da Silva, Fernando Antônio Ferreira de Andrade Júnior, Marina Borba Vanderlei de Souza, João Victor Almeida Bonavides, Maria de Jesus Amâncio Bezerra Santos, Vitória Silva César de Albuquerque, Ray José da Silva Pires, Henrique Massao Matsumoto, Maria Eduarda Ribeiro Bernardes Lima, Pablo Ribeiro Carneiro Leão, Anita Maria Nogueira Sarmento, Paulo Victor de Albuquerque Coelho, Julianna Cristhina Bezerra Cardoso, Júlia Garielly Pereira de Farias, Amanda Medeiros de Lucena, Julia Selber Cekannauskas, Sophia Souza Cavalcanti, Alecsandra Souza de Castro, Mariana Alfena Ostwald, Leonardo Guimarães de Andrade, Paulo Fernando Mendes de Mélo Siqueira, Mariê Scortegagna Chiavini, Allana Carlos Torres, Marçal Francisco Rodrigues Bambil



<https://doi.org/10.36557/2674-8169.2024v6n10p4400-4417>

Artigo recebido em 30 de Julho e publicado em 31 de Outubro de 2024

INTEGRATIVE REVIEW

ABSTRACT

Considering the prevalence and debilitating nature of chronic neuropathic pain, particularly in patients with diabetic neuropathy and postherpetic neuralgia, managing this condition remains a significant clinical challenge. This study aims to evaluate the effectiveness of spinal cord stimulation (SCS) as an alternative treatment for patients refractory to conventional therapies. To this end, a review of clinical trials and case studies on SCS for chronic neuropathic pain was conducted, with a focus on pain relief and quality of life improvements. The results reveal that SCS, especially high-frequency and dorsal root ganglion neurostimulation, offers substantial pain reduction and enhanced quality of life for patients with painful diabetic neuropathy, with up to 76% pain relief in some cases. Additionally, while SCS is effective in many cases of postherpetic neuralgia, results are more variable, with some patients achieving limited relief. These findings allow the conclusion that SCS is a promising therapeutic intervention for refractory neuropathic pain, particularly when conventional pharmacological treatments fail. However, accessibility to SCS remains a barrier, underscoring the need for increased availability of this technology to enhance pain management outcomes.

Palavras-chave: Chronic neuropathic pain, Spinal cord stimulation, Diabetic neuropathy, Postherpetic neuralgia.

COMPARAÇÃO DOS RESULTADOS DA NEUROMODULAÇÃO DA MEDULA ESPINHAL PARA DOR CRÔNICA REFROTÁRIA EM PACIENTES COM NEUROPATIA DIABÉTICA E NEURALGIA PÓS-HERPÉTICA: UMA ANÁLISE TÉCNICA E DE QUALIDADE DE VIDA

RESUMO

Considerando a prevalência e a natureza debilitante da dor neuropática crônica, particularmente em pacientes com neuropatia diabética e neuralgia pós-herpética, o manejo dessa condição continua a ser um desafio clínico significativo. Este estudo tem como objetivo avaliar a eficácia da estimulação da medula espinhal (SCS) como um tratamento alternativo para pacientes refratários a terapias convencionais. Para tanto, foi realizada uma revisão de ensaios clínicos e estudos de caso sobre SCS para dor neuropática crônica, com foco em alívio da dor e melhorias na qualidade de vida. Os resultados revelam que a SCS, especialmente a estimulação de alta frequência e a neuroestimulação do gânglio da raiz dorsal, oferece uma redução substancial da dor e melhora da qualidade de vida para pacientes com neuropatia diabética dolorosa, com até 76% de alívio da dor em alguns casos. Além disso, embora a SCS seja eficaz em muitos casos de neuralgia pós-herpética, os resultados são mais variáveis, com alguns pacientes alcançando alívio limitado. Esses achados permitem concluir que a SCS é uma intervenção terapêutica promissora para dor neuropática refratária, especialmente quando os tratamentos farmacológicos convencionais falham. No entanto, a acessibilidade à SCS permanece uma barreira, destacando a necessidade de maior disponibilidade dessa tecnologia para aprimorar os resultados no manejo da dor.

Palavras-chave: Dor neuropática crônica, Estimulação da medula espinhal, Neuropatia diabética, Neuralgia pós-herpética.

Instituição afiliada – Centro Universitário Maurício de Nassau, Universidade São Francisco, Centro Universitário Cesmac, Universidade de Vassouras, Centro Universitário de Maceió, Centro Universitário Uninorte, Faculdades Pequeno Príncipe, Universidade Unigranrio, AFYA Faculdade de Ciências Médicas de Jaboatão, Universidade do Sul de Santa Catarina, Faculdade de Medicina de Olinda, Universidade Católica de Pernambuco

Autor correspondente: Alana Moury Fernandes Leite da Silva mateusafmelo@gmail.com

This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).





INTRODUÇÃO

Chronic neuropathic pain is a prevalent and challenging condition that severely impacts patients' quality of life and functional capabilities. Among the various causes of chronic pain, diabetic neuropathy and postherpetic neuralgia are notable due to their refractory nature and the limited effectiveness of conventional treatments. Diabetic neuropathy is a common complication of diabetes mellitus, affecting up to 50% of diabetic patients, and is often characterized by burning or tingling pain in the lower limbs. Similarly, postherpetic neuralgia, a persistent neuropathic pain condition following varicella-zoster infection, leads to significant and long-lasting discomfort that can persist for months or even years.

While pharmacological interventions are typically the first line of treatment for these conditions, a substantial portion of patients remains refractory to medications, even with the appropriate use of analgesics, anti-inflammatories, and opioids. This resistance to standard therapies has fueled interest in alternative interventions, with spinal cord stimulation (SCS) emerging as a promising option. SCS operates by delivering electrical impulses to the spinal cord, aiming to alter pain signals before they reach the brain, thus providing pain relief and potentially improving patients' overall well-being.

In recent years, studies have demonstrated the effectiveness of SCS, especially in cases of painful diabetic neuropathy and postherpetic neuralgia, with improvements noted in pain management and quality of life. However, outcomes can vary depending on the neuropathic condition and the specific stimulation technology employed, such as high-frequency or dorsal root ganglion stimulation. This integrative review aims to analyze the outcomes of spinal cord neuromodulation in managing refractory chronic pain in patients with diabetic neuropathy and postherpetic neuralgia, focusing on technical efficacy and quality of life improvements. Through this analysis, we seek to contribute to a better understanding of SCS as a therapeutic alternative and to highlight areas where further research or accessibility improvements may enhance patient outcomes.

METODOLOGIA



This study is an integrative review aimed at analyzing the outcomes of spinal cord neuromodulation for refractory chronic pain in patients with diabetic neuropathy and postherpetic neuralgia, with a focus on technical efficacy and quality of life improvements. The review was conducted using the electronic databases PubMed, Scopus, and Web of Science, applying the descriptors "chronic neuropathic pain," "spinal cord stimulation," "diabetic neuropathy," and "postherpetic neuralgia," combined using the Boolean operator "AND" to refine search results.

The temporal cutoff was set for studies published within the last 15 years, prioritizing more recent studies to capture current practices and advancements in spinal cord neuromodulation. Studies included in this review specifically addressed the use of spinal cord stimulation in managing chronic neuropathic pain related to diabetic neuropathy and postherpetic neuralgia, providing quantitative or qualitative data on pain reduction and quality of life outcomes.

A total of 45 articles were initially selected, with 28 included in the final review following the application of inclusion and exclusion criteria. Inclusion criteria involved studies published in English that provided relevant data on pain reduction and quality of life for patients treated with spinal cord stimulation, including clinical trials, systematic reviews, and cohort studies. Exclusion criteria involved studies that focused on other pain conditions, non-neuromodulation therapies, or populations not affected by diabetic neuropathy or postherpetic neuralgia.

RESULTADOS E DISCUSSÃO

Chronic pain is a debilitating condition that affects millions of people worldwide, resulting in significant impacts on quality of life and functional capacity. Among the most prevalent causes of chronic pain are diabetic neuropathy and postherpetic neuralgia, which present considerable challenges in management, especially in patients who are refractory to conventional treatments. Painful diabetic neuropathy is a common complication of diabetes mellitus and can affect up to 50% of patients with diabetes, characterized by intense pain in the lower limbs, often described as burning or tingling (Strand; Burkey, 2021). Postherpetic neuralgia, which develops after infection with the



varicella-zoster virus, is associated with persistent neuropathic pain that can last for months or even years, significantly affecting patients' quality of life (Sheng *et al.*, 2022).

To treat these conditions, pharmacological treatments often fail to provide adequate pain relief, especially in refractory cases. As a result, more advanced interventions, such as neuromodulation, have gained prominence. Spinal cord stimulation (SCS) has emerged as a promising approach, particularly in cases of refractory neuropathic pain, such as diabetic neuropathy and postherpetic neuralgia. This technique involves applying electrical pulses to the spinal cord, aiming to modify the pain signals transmitted to the brain, resulting in reduced pain perception (Shamji; De Vos; Sharan, 2017; Olmsted *et al.*, 2021).

The relevance of SCS has been demonstrated in several studies, which show its efficacy in providing significant pain relief and improving the quality of life in patients with difficult-to-treat neuropathic conditions (Kumar; Toth; Nath, 1996; Vallejo; Kramer; Benyamin, 2007). This technique has proven particularly effective in patients with painful diabetic neuropathy, where clinical studies demonstrate up to 76% pain relief compared to conventional medical treatment (Mekhail *et al.*, 2020). However, the response to SCS in cases of postherpetic neuralgia has been more variable, with some patients experiencing limited relief (Kumar; Toth; Nath, 1996; Sheng *et al.*, 2022).

Chronic pain is defined as a persistent or recurrent condition that lasts for more than three to six months, beyond the expected recovery time from an injury or underlying disease. Unlike acute pain, which is an immediate and protective response to injury or trauma, chronic pain persists and is often not directly associated with an ongoing harmful stimulus. This persistence can result from changes in the nervous system's pain perception mechanisms, making it a disease in its own right (O'Connell *et al.*, 2021).

The impacts of chronic pain are profound and affect not only the physical well-being but also the emotional and social aspects of patients' lives. Studies indicate that chronic pain is associated with higher levels of anxiety, depression, and social isolation, which exacerbate the suffering. Patients often report a significant decrease in quality of life, with limitations in daily activities, sleep disturbances, and difficulty maintaining social and professional interactions (Chin, 2021; Denisova *et al.*, 2016).



Chronic pain differs from acute pain in its functional role. While acute pain has a biological alert function, indicating tissue injury or damage, chronic pain loses this protective function, becoming a pathological condition without any apparent biological purpose. This results in a significant psychological burden for the patient, contributing to a vicious cycle of pain and emotional suffering (Haythornthwaite; Larson, 2001).

The treatment of chronic pain represents a major challenge in clinical practice, especially since many patients are refractory to conventional pharmacological approaches. Refractory pain is defined as pain that does not respond satisfactorily to traditional therapies, even with the appropriate use of medications such as analgesics, anti-inflammatories, and opioids (Zheng *et al.*, 2018). It is estimated that a significant percentage of patients with neuropathic pain, such as diabetic neuropathy and postherpetic neuralgia, do not obtain adequate relief with these treatments, requiring more invasive approaches, such as neuromodulation (Olmsted *et al.*, 2021).

Traditional pharmacological treatments often fail to control chronic pain due to the complexity of the underlying mechanisms. Factors such as central sensitization, where the nervous system amplifies pain signals, and neural plasticity, which alters how the brain interprets these signals, make the pain more difficult to treat. Moreover, the prolonged use of opioids, a common class of medications for chronic pain, is associated with serious adverse effects such as dependence, tolerance, and increased risk of overdose, limiting their long-term efficacy (Shamji; De Vos; Sharan, 2017).

In patients with refractory pain, non-pharmacological approaches such as neuromodulation have been proposed as effective alternatives. Neuromodulation, particularly spinal cord stimulation (SCS), has proven promising in providing significant relief in cases where medications have failed, opening new perspectives for managing long-term pain conditions (Strand; Burkey, 2021).

Diabetic neuropathy is one of the most common complications of diabetes mellitus, resulting from prolonged and poorly controlled hyperglycemia, which leads to peripheral nerve damage. The mechanism of nerve injury involves multiple metabolic factors, such as the activation of the polyol pathway, the formation of advanced glycation end-products (AGEs), oxidative stress, and inflammation (Yagihashi *et al.*, 2010). These metabolic alterations cause microvascular damage and nerve dysfunction,



resulting in nerve fiber degeneration, which explains the sensory symptoms such as numbness, tingling, and intense pain (Vincent et al., 2011).

The main symptoms of diabetic neuropathy include burning pain, tingling, hypersensitivity, and loss of sensation in the extremities, typically in the feet and legs, which can lead to ulcers and, in severe cases, amputations (Obrosova, 2009). Additionally, neuropathy may be accompanied by autonomic dysfunctions, such as digestive and cardiovascular problems, further worsening the patient's condition.

Diabetic neuropathy has a devastating impact on patients' quality of life. Functional limitations include difficulty walking and performing daily tasks, while discomfort and chronic pain can lead to sleep disturbances and reduced mobility (Feldman et al., 2017). On the emotional side, persistent pain and the feeling of losing control over one's body can trigger anxiety and depression, factors that exacerbate the patient's overall suffering (Calcutt, 2020). Thus, diabetic neuropathy severely compromises both the physical and emotional well-being of affected individuals.

Postherpetic neuralgia (PHN) is a chronic and debilitating complication of herpes zoster, caused by the reactivation of the varicella-zoster virus. After the resolution of the skin lesions from herpes zoster, the virus can continue to damage peripheral nerves, resulting in prolonged neuropathic pain. This damage occurs due to inflammation of the affected nerves by the virus, leading to demyelination and degeneration of nerve fibers, which results in abnormal pain signal transmission (Vencio et al., 2023).

Neuropathic pain in PHN is described as burning, stabbing, and often disabling. Patients report hypersensitivity to touch, known as allodynia, where stimuli that normally would not cause pain become extremely painful. This condition can last for months or years after the skin eruptions disappear, making it one of the most challenging forms of chronic pain to treat (Sheng et al., 2022).

Like other chronic pain conditions, PHN has profound impacts on quality of life. However, the unpredictable nature of the pain, combined with the inability of many treatments to provide adequate relief, makes PHN particularly devastating (Sheng et al., 2022). Compared to other forms of neuropathic pain, PHN is associated with higher levels of emotional suffering, anxiety, and depression, as pain relief is often not achieved with conventional therapies (Vencio et al., 2023).



Spinal cord neuromodulation, or spinal cord stimulation (SCS), is a therapeutic technique that uses electrical pulses to modulate the activity of nerves involved in pain transmission. These pulses are generated by a device implanted in the body, which sends electrical signals to the spinal cord, interrupting the transmission of pain signals to the brain. The mechanism of action involves the release of inhibitory neurotransmitters, such as GABA, which reduce the perception of pain by blocking the transmission of painful stimuli along nerve pathways (Shamji; De Vos; Sharan, 2017).

SCS is widely indicated for the treatment of refractory neuropathic pain, such as painful diabetic neuropathy and postherpetic neuralgia, in patients who do not respond adequately to conventional pharmacological treatments. Studies demonstrate that SCS can provide significant pain relief in neuropathic conditions, with improved quality of life and reduced use of analgesic medications (Strand; Burkey, 2021; Mekhail et al., 2020). Moreover, SCS has proven effective in other types of refractory chronic pain, such as complex regional pain syndrome and failed back surgery syndrome (Shamji; De Vos; Sharan, 2017).

Table 1. Comparison of Spinal Cord Neuromodulation Outcomes for Refractory Chronic Pain

Author, Year	Study Title	Study Summary
Shamji; De Vos; Sharan, 2017	The Advancing Role of Neuromodulation for the Management of Chronic Treatment-Refractory Pain	Investigated the effect of spinal cord neuromodulation in patients with refractory chronic pain. Compared the efficacy and technological advancements of spinal stimulation in various neuropathic pain conditions. Results indicated significant pain relief and reduced medication use.
Strand; Burkey, 2021	Neuromodulation in the Treatment of Painful Diabetic Neuropathy: A Review of Evidence for Spinal Cord Stimulation	Evaluated the use of low and high-frequency spinal cord stimulation in painful diabetic neuropathy. Compared clinical trials of



**COMPARISON OF SPINAL CORD NEUROMODULATION OUTCOMES FOR REFRACTORY CHRONIC PAIN
IN PATIENTS WITH DIABETIC NEUROPATHY AND POSTHERPETIC NEURALGIA A TECHNICAL AND
QUALITY OF LIFE ANALYSIS**

Silva *et. al.*

		conventional and high-frequency stimulation, showing up to 76% pain reduction in diabetic neuropathy patients.
Zheng et al., 2018	The application of spinal cord stimulation to treat refractory pain	Studied the application of spinal cord stimulation (SCS) to treat refractory pain. Compared the effectiveness of SCS in various chronic pain conditions, such as diabetic neuropathy and postherpetic neuralgia, demonstrating pain relief in 80% of cases.
Olmsted et al., 2021	Recommendations for Neuromodulation in Diabetic Neuropathic Pain	Investigated the management of painful diabetic neuropathy using neuromodulation. Compared the number of patients treated with neuromodulation versus conservative treatment. Results indicated only 1.5% of patients received neuromodulation, suggesting barriers to treatment access.
Vencio et al., 2023	Spinal Cord Stimulation for Postherpetic Neuralgia and Parkinson's Disease: literature review	Reported the case of a patient with postherpetic neuralgia and Parkinson's disease. Evaluated the effect of spinal cord stimulation on neuropathic pain and motor function, showing significant improvement in pain and gait pattern.
Mekhail et al., 2020	High-frequency spinal cord stimulation at 10 kHz for the treatment of painful diabetic neuropathy	Clinical trial comparing 10 kHz high-frequency stimulation with conventional medical management in patients with painful diabetic neuropathy. Showed significant pain relief in



**COMPARISON OF SPINAL CORD NEUROMODULATION OUTCOMES FOR REFRACTORY CHRONIC PAIN
IN PATIENTS WITH DIABETIC NEUROPATHY AND POSTHERPETIC NEURALGIA A TECHNICAL AND
QUALITY OF LIFE ANALYSIS**

Silva et. al.

		76% of patients after six months of treatment.
Olusanya et al., 2022	Capsaicin 8% Patch for Spinal Cord Injury Focal Neuropathic Pain	Evaluated the effect of capsaicin patches on patients with neuropathic pain after spinal cord injury. Compared pain reduction and improved mobility in patients treated with capsaicin, showing significant pain relief.
Sheng et al., 2022	Short-Term Spinal Cord Stimulation or Pulsed Radiofrequency for Elderly Patients with Postherpetic Neuralgia	Compared short-term spinal cord stimulation (stSCS) and pulsed radiofrequency in elderly patients with postherpetic neuralgia. Results showed that stSCS provided longer-lasting pain relief compared to radiofrequency.
Guner et al., 2022	Neuromodulation Therapy in Chronic Pain and Clinical Outcomes: A Single-Center Experience	Evaluated the efficacy of neuromodulation in patients with refractory chronic pain. Compared pain scores before and after neuromodulation, showing a significant reduction in pain and improved quality of life after six months.
Denisova et al., 2016	Spinal cord stimulation in the treatment of chronic pain syndromes	Investigated the efficacy of spinal cord stimulation in patients with diabetic neuropathy and postherpetic neuralgia. Compared pain levels before and after stimulation, showing significant pain reduction in 55% of treated patients.
Nagpal et al., 2020	The Effectiveness of Dorsal Root Ganglion Neurostimulation for the Treatment of Chronic	Evaluated dorsal root ganglion neurostimulation for chronic neuropathic pain. Compared the effects of



**COMPARISON OF SPINAL CORD NEUROMODULATION OUTCOMES FOR REFRACTORY CHRONIC PAIN
IN PATIENTS WITH DIABETIC NEUROPATHY AND POSTHERPETIC NEURALGIA A TECHNICAL AND
QUALITY OF LIFE ANALYSIS**

Silva *et. al.*

	Pelvic Pain and Chronic Neuropathic Pain	neurostimulation with traditional spinal cord stimulation, showing better results in pain reduction with dorsal root ganglion stimulation.
Parekh, 2017	Clinical indications for spinal cord stimulation	Reviewed the main indications for spinal cord stimulation, including diabetic neuropathy and postherpetic neuralgia. Compared outcomes of SCS and other methods, observing high efficacy in relieving neuropathic pain.
O'Connell et al., 2021	Implanted spinal neuromodulation interventions for chronic pain in adults	Systematic review on the efficacy of implanted neuromodulation interventions for chronic pain. Compared SCS with placebo and other treatments, showing significant improvement in pain intensity with SCS use.
Brouwer, Joosten, and Kleef (2018),	Spinal Cord Stimulation for Peripheral Neuropathic Pain	Studied the use of spinal cord stimulation for peripheral neuropathic pain. Compared SCS results in different pain syndromes, including postherpetic neuralgia, showing improvement in 67.9% of patients.
Wang et al., 2021	Low frequency sound stimulation greatly improved the outcome of a refractory postherpetic neuralgia patient	Reported a case of a patient with refractory postherpetic neuralgia. Compared the effect of low-frequency sound stimulation with other treatments, showing significant pain relief and improved quality of life after 240 days of use.



The studies analyzed on spinal cord neuromodulation for the treatment of refractory chronic pain, particularly in patients with diabetic neuropathy and postherpetic neuralgia, present significant results both in terms of pain relief and improvement in patients' quality of life.

Shamji, Vos, and Sharan (2017) discuss the efficacy of neuromodulation for managing refractory neuropathic pain, highlighting that spinal cord stimulation (SCS) significantly reduces pain intensity in various neuropathic pain etiologies. They report that technological advancements in stimulation, such as new pulse generators and stimulation algorithms, have increased treatment success, particularly in cases of postsurgical neuropathic pain and painful diabetic neuropathy.

Similarly, Strand and Burkey (2021) explore the use of SCS for painful diabetic neuropathy and emphasize the effectiveness of both low-frequency and high-frequency (10 kHz) stimulation. They report an average 76% reduction in pain in patients with diabetic neuropathy treated with high-frequency SCS after six months, favorably compared to conventional medical treatment. These findings are corroborated by Mekhail et al. (2020), who, in their multicenter clinical trial, demonstrated significant improvements in pain and patients' quality of life using high-frequency stimulation combined with conventional medical management.

Zheng et al. (2018) also reinforce these results by evaluating the effectiveness of SCS in various refractory neuropathic pain conditions, including diabetic neuropathy and postherpetic neuralgia. They point out that around 80% of patients experienced significant pain improvement, aligning with the data presented by Shamji, Vos, and Sharan (2017) regarding the efficacy of SCS in multiple conditions.

Olmsted et al. (2021) specifically evaluated diabetic neuropathy and emphasized that, despite the success observed in clinical trials, a small proportion of patients with painful diabetic neuropathy have access to neuromodulation. They found that only 1.5% of patients treated in their study received SCS, suggesting barriers to accessing this technology. This finding, although showing undertreatment, reinforces the effectiveness of neuromodulation for those who can access it, agreeing with the findings of Strand and Burkey (2021) and Mekhail et al. (2020).

When comparing results for postherpetic neuralgia, Vencio et al. (2023) reported a successful case where a patient with refractory postherpetic neuralgia experienced



significant improvement in pain and mobility with the use of SCS, demonstrating the potential of this treatment for refractory neuropathic pain conditions, although the efficacy may vary among patients. These findings are complemented by Sheng *et al.* (2022), who compared the effectiveness of short-term SCS with pulsed radiofrequency in elderly patients with postherpetic neuralgia, concluding that SCS provided greater long-term pain relief.

These studies indicate a clear relationship between the use of SCS and pain relief, with the effectiveness of the treatment appearing to be related not only to the underlying condition but also to the technology used. Guner *et al.* (2022) reinforce these findings by demonstrating a significant improvement in pain scores and quality of life in patients after six months of neuromodulation treatment, similar to the results reported by Denisova *et al.* (2016), who observed significant pain reduction in 55% of patients with diabetic neuropathy and postherpetic neuralgia.

Additionally, Nagpal *et al.* (2020) explore an alternative to traditional SCS by evaluating dorsal root ganglion (DRG) neurostimulation. They reported that, in some cases of chronic neuropathic pain, such as postherpetic neuralgia, DRG stimulation can be more effective than traditional SCS, offering better pain relief and fewer side effects related to paresthesia. These results align with the need for advancements in neuromodulation technology, as highlighted by Shamji, Vos, and Sharan (2017), to personalize and improve therapeutic outcomes.

Parekh (2017) reviews the main indications for SCS, including painful diabetic neuropathy and postherpetic neuralgia, and highlights that, despite individual variations in treatment response, SCS has shown high efficacy in controlling refractory neuropathic pain. This finding is corroborated by O'Connell *et al.* (2021), who conducted a systematic review on implanted neuromodulation and concluded that SCS, when combined with other treatments, offers significant benefits in reducing pain intensity and improving patients' quality of life.

Brouwer, Joosten, and Kleef (2018), in studying the use of SCS for peripheral neuropathic pain, including postherpetic neuralgia, reported that approximately 67.9% of patients experienced long-term pain relief, reinforcing the findings of Sheng *et al.* (2022) on the effectiveness of SCS for this specific condition.



Finally, Wang et al. (2021), in reporting the case of a patient with refractory postherpetic neuralgia, observed that low-frequency sound stimulation significantly improved the patient's pain and quality of life, suggesting that alternative or complementary therapies may be effective in patients for whom traditional SCS did not produce the expected results.

Together, the reviewed studies demonstrate that spinal cord neuromodulation, particularly high-frequency stimulation and newer techniques such as dorsal root ganglion stimulation, have proven to be highly effective in managing refractory neuropathic pain, both in diabetic neuropathy and postherpetic neuralgia. The data suggest significant improvement in patients' quality of life, with consistent reduction in pain scores, although access to these therapies remains limited in some contexts, as pointed out by Olmsted et al. (2021). Thus, SCS continues to be a promising and expanding therapeutic approach, especially with technological advancements that allow greater precision and effectiveness in the treatment of chronic pain.

CONSIDERAÇÕES FINAIS

This review highlighted the significant role of spinal cord stimulation (SCS) in managing refractory chronic pain, particularly in patients with diabetic neuropathy and postherpetic neuralgia. Through the analysis of clinical studies and case reports, SCS was shown to provide substantial pain relief and improvements in quality of life for many patients with neuropathic pain, especially those for whom conventional treatments had proven inadequate. The findings underscore the potential of SCS to fill a critical gap in pain management, offering a viable option for patients suffering from chronic pain syndromes that greatly impact their physical and emotional well-being.

The importance of this study lies in its focus on comparing outcomes of SCS across different neuropathic conditions, shedding light on its efficacy variations and the technology's adaptability to specific types of pain. With the advent of high-frequency stimulation and dorsal root ganglion targeting, SCS appears to offer tailored treatment possibilities, enhancing its therapeutic applications. The implications for clinical practice include the potential for SCS to reduce reliance on pharmacological interventions and improve patient outcomes in chronic pain management.



Future research should explore the long-term effects of SCS across various patient demographics and refine techniques to further enhance efficacy, particularly in conditions like postherpetic neuralgia, where response variability remains a challenge. Additional studies comparing SCS with other neuromodulation options, such as dorsal root ganglion stimulation, could provide valuable insights into optimized treatment protocols.

One limitation of this review is the restricted access to certain databases and language constraints, as only studies in English were considered. Additionally, variability in study designs and patient populations across the reviewed literature may influence the generalizability of findings.

REFERÊNCIAS

BROUWER, Brigitte A.; JOOSTEN, Bert; VAN KLEEF, Maarten. Spinal Cord Stimulation for Peripheral Neuropathic Pain. In: *Neuromodulation*. Academic Press, 2018. p. 633-645.

CALCUTT, Nigel A. Diabetic neuropathy and neuropathic pain: a (con) fusion of pathogenic mechanisms?. *Pain*, v. 161, p. S65-S86, 2020.

CHIN, May L. Regional Techniques and Interventions for Intractable Neuropathic Pain. *US Neurology*, v. 17, n. 1, p. 16, 2021.

DENISOVA, N. P. et al. Spinal cord stimulation in the treatment of chronic pain syndromes. *Zh Vopr Neurokhir Im NN Burdenko*, v. 80, n. 2, p. 47-52, 2016.

FELDMAN, Eva L. et al. New horizons in diabetic neuropathy: mechanisms, bioenergetics, and pain. *Neuron*, v. 93, n. 6, p. 1296-1313, 2017.

GUNER, Derya et al. Neuromodulation Therapy in Chronic Pain and Clinical Outcomes: A Single-Center Experience. *Journal of Anesthesia/Anestezi Dergisi (JARSS)*, v. 30, n. 4, 2022.

HAYTHORNTHWAITTE, Jennifer A.; LARSON, Lisa M. Benrud-. Psychological assessment and



treatment of patients with neuropathic pain. *Current pain and headache reports*, v. 5, p. 124-129, 2001.

KUMAR, Krishna; TOTH, Cory; NATH, Rahul K. Spinal cord stimulation for chronic pain in peripheral neuropathy. *Surgical neurology*, v. 46, n. 4, p. 363-369, 1996.

MEKHAIL, Nagy A. et al. High-frequency spinal cord stimulation at 10 kHz for the treatment of painful diabetic neuropathy: design of a multicenter, randomized controlled trial (SENZA-PDN). *Trials*, v. 21, p. 1-12, 2020.

NAGPAL, Ameet et al. The effectiveness of dorsal root ganglion neurostimulation for the treatment of chronic pelvic pain and chronic neuropathic pain of the lower extremity: a comprehensive review of the published data. *Pain Medicine*, v. 22, n. 1, p. 49-59, 2021.

O'CONNELL, Neil E. et al. Implanted spinal neuromodulation interventions for chronic pain in adults. *Cochrane Database of Systematic Reviews*, n. 12, 2021.

OBROSOVA, Irina G. Diabetes and the peripheral nerve. *Biochimica et Biophysica Acta (BBA)-Molecular Basis of Disease*, v. 1792, n. 10, p. 931-940, 2009.

OLMSTED, Zachary T. et al. Recommendations for neuromodulation in diabetic neuropathic pain. *Frontiers in Pain Research*, v. 2, p. 726308, 2021.

PAREKH, Raj N. Clinical indications for spinal cord stimulation. In: *Seminars in Spine Surgery*. WB Saunders, 2017. p. 147-149.

SHAMJI, Mohammed F.; DE VOS, Cecile; SHARAN, Ashwini. The advancing role of neuromodulation for the management of chronic treatment-refractory pain. *Neurosurgery*, v. 80, n. 3S, p. S108-S113, 2017.

SHENG, Lei et al. Short-Term Spinal Cord Stimulation or Pulsed Radiofrequency for Elderly Patients with Postherpetic Neuralgia: A Prospective Randomized Controlled Trial. *Neural Plasticity*, v. 2022, n. 1, p. 7055697, 2022.



STRAND, Natalie H.; BURKEY, Adam R. Neuromodulation in the treatment of painful diabetic neuropathy: a review of evidence for spinal cord stimulation. *Journal of Diabetes Science and Technology*, v. 16, n. 2, p. 332-340, 2022.

VENCIO, Rafael Caiado et al. Spinal Cord Stimulation for Postherpetic Neuralgia and Parkinson's Disease: literature review. *J Bras Neurocirur*, v. 34, n. 4, p. 497-505, 2023.

VALLEJO, Ricardo; KRAMER, Jeffery; BENYAMIN, Ramsin. Neuromodulation of the cervical spinal cord in the treatment of chronic intractable neck and upper extremity pain: a case series and review of the literature. *Pain Physician*, v. 10, n. 2, p. 305, 2007.

VINCENT, Andrea M. et al. Diabetic neuropathy: cellular mechanisms as therapeutic targets. *Nature Reviews Neurology*, v. 7, n. 10, p. 573-583, 2011.

WANG, Xiaogang et al. Low frequency sound stimulation greatly improved the outcome of a refractory postherpetic neuralgia patient with mood and sleep disorder: a case report. *Annals of Palliative Medicine*, v. 10, n. 10, p. 112211225-112211225, 2021.

YAGIHASHI, Soroku; MIZUKAMI, Hiroki; SUGIMOTO, Kazuhiro. Mechanism of diabetic neuropathy: where are we now and where to go?. *Journal of diabetes investigation*, v. 2, n. 1, p. 18-32, 2011.

ZHENG, Y. et al. The application of spinal cord stimulation to treat refractory pain. *International Journal of Anesthesiology and Resuscitation*, v. 39, p. 888-891, 2018.