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Transcutaneous Electrical Nerve Stimulation (TENS) and Photobiomodulation promote improvement in Cervical Radicular Pain Due to Disc Herniation? Case Study

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Abstract

Cervical disc herniation (CDH) is caused by prolapse of the nucleus pulposus, which presses on nerve roots or the spinal cord in the neck, causing neuropathic pain due to nerve dysfunction or compression, mainly in the C5-C6 and C6-C7 roots, resulting in symptoms such as chronic pain, burning and allodynia in the ipsilateral arm. The objective of this study is to evaluate the combined therapy of Transcutaneous Electrical Nerve Stimulation (TENS) and photobiomodulation to stimulate nerve fibers and increase cellular energy production, aiming at the reduction of pain and inflammation. This non-invasive and non-pharmacological method aims to provide a faster therapeutic response than conventional therapy, resulting in well-being and quality of life for the patient. The study was carried out at the Photodynamic Therapy Unit of Santa Casa (PTU) - São Carlos, with 1 male patient, 49 years old, diagnosed with disc herniation in the cervical region (C5-C6), with radiating pain in the right upper limb and functional limitations, such as restrictions of cervical spine movements. The methods used were the prototype equipment that consists of the synergy of electric current emissions (TENS) and Laser. The protocol consisted of 10 treatment sessions, twice a week, lasting 30 minutes, using synergistically the TENS with continuous stimulation of 100Hz, 100μs and sensory intensity, and the therapeutic laser of 660nm and 808nm, applied in the region of the corresponding dermatome. As a form of evaluation, the goniometric measurement of the articular angles of the cervical spine, the Visual Analogue Scale (VAS), the Neck Disability Index Questionnaire (NDI) and the Quality of Life Questionnaire SF-36 were used. The results obtained were improvement and greater amplitude in relation to movements, reduction in relation to pain, reflected in the increase in functional capacity, reduction of limitations caused by physical and emotional problems, greater vitality, improvement in the general state of health, greater participation in social activities and reduction of symptoms of anxiety and stress. This case study with the synergistic use of TENS and photobiomodulation as a resource for pain relief in inflammation and joint movements due to CDH, contributed to emotional well-being and an overall improvement in the patient's quality of life in 5 weeks of treatment.

Keywords: Transcutaneous electrical nerve stimulation; Laser; Photobiomodulation; Pain; Cervical disc herniation

Introduction

Cervical disc herniation (CDH) is a condition caused by the prolapse of the nucleus pulposus material, which is projected out of its normal location, putting pressure on the nerve roots or spinal cord in the neck region. Its incidence is 83.2 per 100,000 people, of which 107.3 are men and 63.5 are women [1,2].

Radicular pain caused by CDH is classified as neuropathic pain due to dysfunction or compression of a nerve in the cervical spine, the nerve roots, or both, causing irritation and amplifying the sensitivity of nerve fibers, which can lead to a state of hyperexcitability in the peripheral nerves and central nervous system [3-7].

The most commonly affected nerve roots are C5-C6 and C6-C7, which innervate and radiate symptoms such as chronic pain, stinging, burning accompanied by allodynia and hyperalgesia to the ipsilateral arm, in the distribution of dermatomes (neck, shoulder, arm and hand region) leading to disability and suffering in the daily lives of this population [2,8,9].

There are treatments for radicular pain caused by CDH, such as conservative treatments, which are initially indicated, including physical therapy with active and passive kinesiotherapy and electrostimulation procedures, pain medication and periradicular steroid injections under computerized imaging guidance. Surgical treatment is indicated for cases of intractable pain, such as anterior cervical discectomy, interbody fusion and others [1,9].

This case study brought a new non-invasive and non-pharmacological technological treatment through a portable electronic device, which consists of the synergism of electrical current emissions (TENS- transcutaneous electrical nerve stimulation and/or FES - functional electrical stimulation) and Laser, operating at wavelengths of 660nm and/or 808nm, which can be simultaneous or alternated during

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the same therapeutic application.

Applications can be made in different areas of the human body with the purpose of accelerating the tissue process, muscle rehabilitation, reducing inflammation and pain, stimulating muscle strengthening and/or re-education, reducing muscle spasms, providing the patient and the health system with a shorter treatment time in the rehabilitation of various pathologies.

Transcutaneous electrical nerve stimulation (TENS) works by applying electrical currents to the surface of the skin through electrodes to stimulate nerve fibers for the effects of analgesia, muscle stimulation, vasodilation, reduction of edema, reduction of reflex inhibition, facilitation of healing of soft tissue injuries and facilitation of fracture consolidation. Functional electrical stimulation (FES) also works by applying electrodes to activate the muscles in a coordinated and sequenced manner through the nerve fibers. Both electrical stimulations can reduce spasticity in up to 4 hours [10,11].

Low-power laser (660nm and 808nm) has analgesic, anti-inflammatory and healing effects, due to the low energy densities used and wavelengths capable of penetrating tissues [12,13].

With this form of intervention, this study aims to evaluate the combined therapy of TENS and photobiomodulation, aiming to stimulate nerve fibers and increase energy production in cells, to reduce pain, inflammation and provide a faster therapeutic response than conventional therapy, in a non-invasive and non-pharmacological way, resulting in well-being and quality of life for the patient.

Materials and Method

Study and patient

This case study was approved by the Human Research Ethics Committee under number CAAE 70562523.2.0000.814 and carried out at the Photodynamic Therapy Unit (Santa Casa Hospital)/Institute of Physics of São Carlos - University of São Paulo - São Carlos, São Paulo, Brazil. A 49-year-old white male patient presented a medical report reporting a herniated disc in the cervical region (C5-C6) with radiating pain in the right upper limb and functional limitations, such as restricted movement of the cervical spine (flexion 10º (0º to 65º), extension 10º (0º to 50º), right lateral flexion 5º (0º to 40º), left lateral flexion 10º (0º to 40º), right rotation 5º (0º to 55º) and left rotation 10º (0º to 55º) impacting activities of daily living for more than 3 months.

Equipment and protocol

The prototype equipment has patent process number BR 10 2025 001000 3, which was developed by the Technical Support Laboratory of the Physics Institute of São Carlos of the University of São Paulo and consists of the synergism of the emissions of electrical currents (TENS - transcutaneous electrical nerve stimulation) and Laser. The electrical stimulation is conducted from one electrode to the other, firmly fixed to the skin. Among the electrodes, the light emission head has four light emitters (two with wavelengths in the red range (660nm) and two with wavelengths in the infrared range (808nm). These emitters radiate light perpendicularly to the skin surface, interacting with the stimulus generated by electrical stimulation. In this way, there is an overlap of therapeutic resources, enhancing the effects of the treatment (Figure 1). The protocol consisted of 10 treatment sessions, twice a week, lasting 30 minutes, synergistically using a 660nm and 808nm therapeutic laser (100mW - 3.6J/cm2 for each head), and TENS with continuous stimulation of 100Hz, 100μs and sensory intensity.

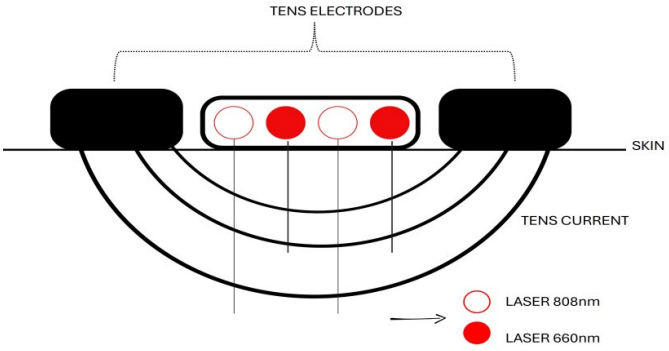

Figure 1: Illustration of the overlap of therapeutic fields promoted by Transcutaneous Electrical Nerve Stimulation (TENS) and Low-Level Laser Therapy.

Area of application

The application region was directed both to the anatomical projection area of the vertebral segment and along the corresponding dermatome (neck region; upper and lateral part of the shoulder; upper part of the arm up to the level of the elbow and forearm) (Figure 1).

Evaluation mechanisms

As a form of assessment, changes in the condition of execution of movements were analyzed through goniometric analysis of the measurement of the joint angles of the cervical spine (flexion, extension, left lateral flexion, right lateral flexion, left rotation and right rotation, the Visual Analogue Scale (VAS) which consists of assisting in measuring the intensity of pain in the patient, the Neck Disability Index (NDI) Questionnaire which analyzes the disability related to neck pain and the Quality of Life Questionnaire (SF-36) which evaluates the quality of life related to health at two moments, before treatment and after the 10th treatment session.

Results

The results obtained were compared before and after treatment through the synergistic intervention of TENS and Laser in patients with herniated discs in the cervical spine in relation to the movements of flexion, extension, left lateral flexion, right lateral flexion, left rotation and right rotation of the cervical spine, showing improvement and a greater amplitude in relation to the movements: Flexion from 10º to 65º; Extension from 10º to 45º; Left lateral flexion from 10º to 35º; Right lateral flexion from 5º to 30º; Left rotation from 10º to 45º and Right rotation from 5º to 40º (Figure 3).

In the comparison of pre and post EVA in treatment through the synergistic intervention of TENS and Laser in a patient suffering from a Herniated Disc in the cervical spine, there was a reduction in pain, demonstrating an improvement from EVA 9 to 2 (Figure 4).

In the comparison of pre and post NDI in treatment through the synergistic intervention of TENS and Laser in a patient suffering from a Herniated Disc in the cervical spine, they indicated a substantial improvement, with a reduction in the total score from 31 to 7, reflecting a lesser impact of cervical pain on daily activities (Figure 5).

In the comparison of pre and post SF-36 in treatment through the synergistic intervention of TENS and Laser in a patient affected by Herniated Disc in the cervical spine, they demonstrated improvement in all domains evaluated. An increase in functional capacity from 35 to 75, reduction of limitations caused by physical problems from 25 to 75

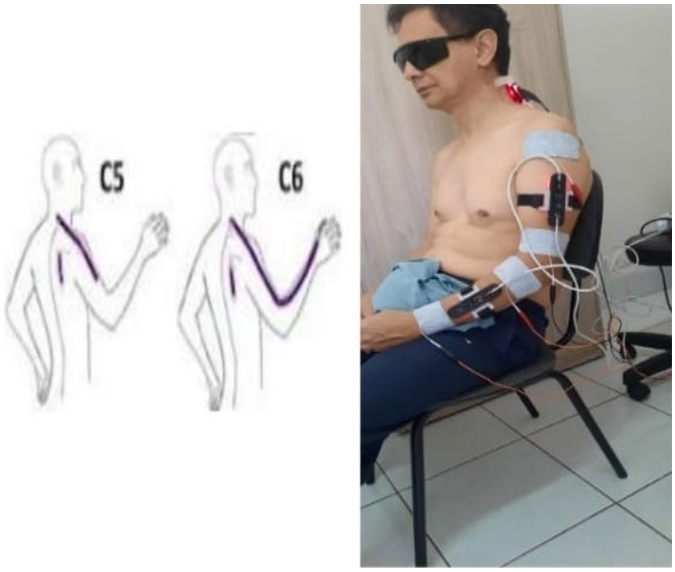

Figure 2: Illustration of the area of symptoms of Radicular Pain in the Cervical Spine and region applied through the synergistic resources of Electrical Stimulation (TENS) and Laser.

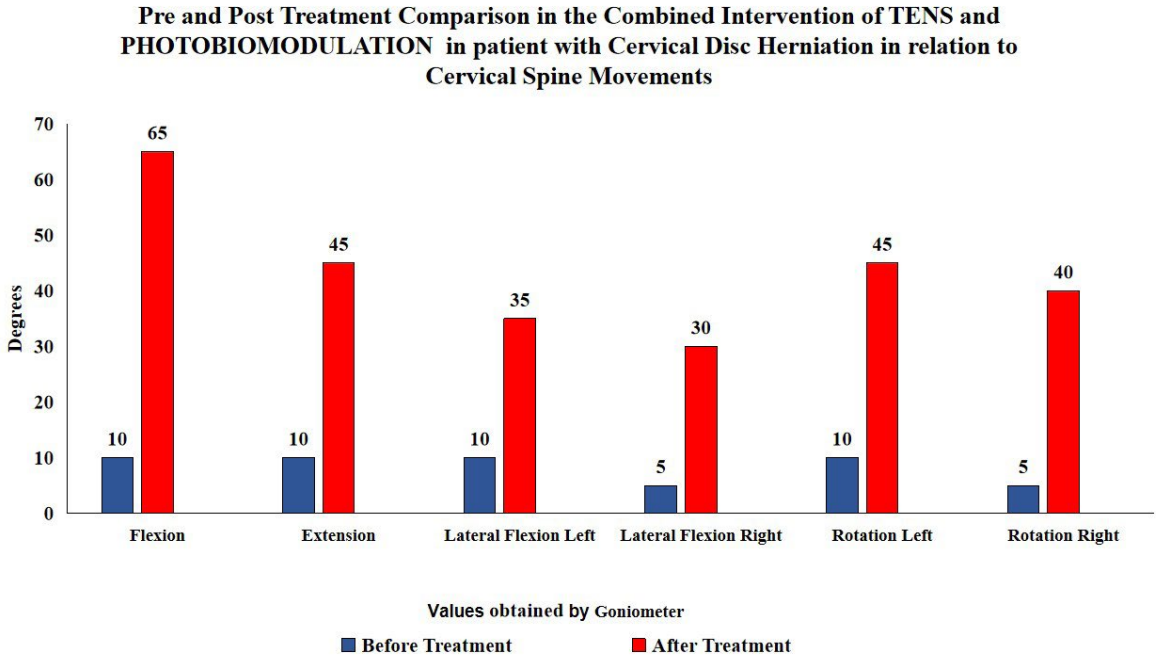

Figure 3: Comparison of pre and post treatment using the synergistic resources TENS and Laser in a patient suffering from a herniated disc in the cervical spine in relation to the movements performed by the cervical spine joint.

and emotional from 40 to 80, pain relief from 20 to 80, greater vitality from 35 to 75, improvement in general health status from 35 to 75, greater participation in social activities from 40 to 80 and in addition, the mental health domain showed significant improvement from 40 to 80, reducing symptoms of anxiety and stress, contributing to emotional well-being, indicating an overall evolution in the patient's quality of life (Figure 6).

Discussion

CDH is a chronic degenerative disease in which the intervertebral discs are injured, occurring mainly at the C5-C6 and C6-C7 levels. They are caused by compression and inflammation of the spinal nerves or nerve roots of the spine, resulting in radicular pain, leading to symptoms such as chronic pain, stinging, burning accompanied by allodynia and hyperalgesia with irradiation to the ipsilateral arm in the distribution of the dermatomes (neck, shoulder, arm and hand region) [2,8,9].

Pain occurs due to the release of pro-inflammatory substances such as prostaglandins, cytokines and tumor necrosis factor alpha, which induce pain, leading to an inflammatory reaction at the site [1]. These agents promote local inflammation by reducing the activation threshold of nociceptors, making them hyperexcitable [14]. As a result, nerve fibers, especially type C, begin to continuously trigger pain signals,

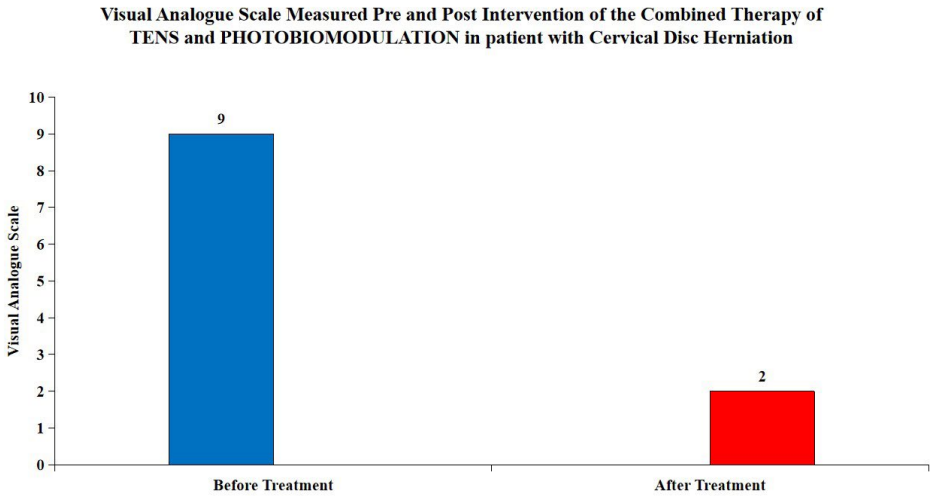

Figure 4: Comparison of pre and post treatment using the synergistic resources TENS and Laser in a patient suffering from a herniated disc in the cervical spine in relation to the Visual Analogue Scale.

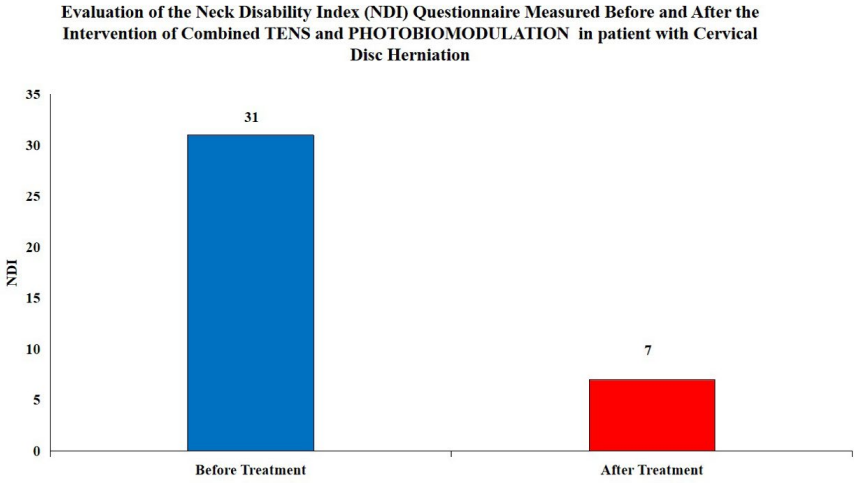

Figure 5: Comparison of pre and post treatment using the synergistic resources TENS and Laser in a patient suffering from a herniated disc in the cervical spine in relation to the Neck Disability Index (NDI) Questionnaire.

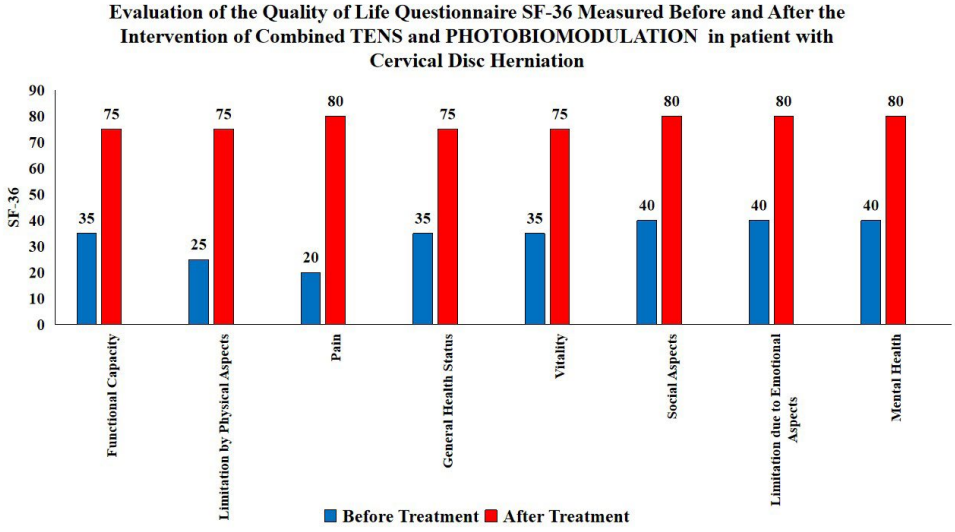

Figure 6: Comparison of pre and post treatment using the synergistic resources TENS and Laser in a patient suffering from a herniated disc in the cervical spine in relation to the SF-36 Quality of Life Questionnaire.

even in the absence of stimuli. This leads to an intensification of pain due to the excess of excitatory neurotransmitters, such as glutamate and substance P. With this uncontrolled increase, the inhibition mechanisms begin to have their function compromised, resulting in a persistent amplification of pain signals [15].

Therefore, treatments for radicular pain caused by CDH begin with conservative treatments associated with rest, physiotherapy, oral medication and steroid injections. If this does not result in improvement, surgical treatment is indicated [9]

A study by Schoenfeld, et al. [16], between 70% and 95% of patients with radicular pain in the cervical spine demonstrated substantial improvement with conservative approaches, such as therapies, exercises, anti-inflammatories and/or epidural corticosteroid injections.

Furthermore, in the study by Wong, et al. [17] and Thoomes, et al. [18], the authors indicated that 83% of patients with cervical radicular pain due to CDH showed significant improvements 4 to 6 months after the start of treatment. The time to complete recovery was reported to be 24 to 36 months in most patients.

As a result, researchers from the São Carlos Physics Institute at the University of São Paulo have been demonstrating in articles that the combination of two physiotherapy resources promotes an overlapping of therapeutic effects, enhancing the treatment. These international publications prove that this approach accelerates the relief of pain and inflammation, significantly reducing recovery time [19-22].

Therefore, one of the synergistic resources used in the present study that emits electrical stimuli was TENS. Research indicates that TENS can alleviate acute and chronic pain of various origins. When applied at high frequency, as was used in this study, TENS aims to produce Aβ, which causes a depolarization effect on the fibers, inhibiting the transmission of sensory information to the spinal cord. TENS also activates opioid receptors in the central nervous system, such as serotonin, MU (μ-opioid) and delta δ-opioid receptors [23-27].

The other resource used was low-intensity laser (LBP), which acts through photobiomodulation, stimulating cellular processes without causing thermal damage to tissues. Some studies demonstrate that laser can directly influence the structures of the neural system that present damage due to compression and/or inflammation [28]. Inflammation is modulated and reduces the expression of pro-inflammatory mediators, such as IL-1β, TNF-α and prostaglandins, while increasing anti-inflammatory cytokines, such as IL-10, helping to minimize the inflammatory process in the affected region. In addition, LBP promotes pain relief by inhibiting the activity of nociceptive fibers, such as C and Aδ fibers, reducing the release of pain-related substances, such as substance P, stimulating the production of endorphins and enkephalins and decreasing the conduction of painful stimuli in peripheral nerves. It also contributes to tissue repair by increasing ATP synthesis in mitochondria through stimulation of cytochrome C oxidase, providing more energy for cell regeneration processes. Another beneficial effect of laser is the improvement of microcirculation and tissue oxygenation, which occurs through stimulation of angiogenesis and increased local blood flow, favoring the transport of nutrients and oxygen to the intervertebral disc and surrounding tissues. In addition, LBP helps in the reorganization of collagen fibers and modulation of the extracellular matrix, which contributes to the recovery of structures compromised by hernia compression [29-33].

One fact observed in this study is the strong relationship between the desensitization of the patient's pain and the improvement in functionality that became evident after the sixth session. A possible explanation would be the enhancement of these therapeutic effects, providing immediate pain relief with TENS and a prolonged benefit due to the anti-inflammatory and regenerative action of the laser, allowing the resumption of strengthening exercises for stabilizing the spine, which are fundamental for full recovery, thus contributing to an improvement in the patient's quality of life.

Conclusion

This case study allowed us to deepen our knowledge about TENS and photobiomodulation treatments as a resource for pain relief in inflammation and joint movements, providing greater functionality, reducing the patient's treatment period to 5 weeks, restoring their quality of life. This ongoing study may bring a new perspective to the non-invasive and non-pharmacological treatment of cervical disc herniation.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgement

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