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Case Report

Use of Super Pulsed Laser in the Treatment of Chronic Pain Secondary to Burns: Literature Review and Case Report

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ABSTRACT

Burns are skin lesions that can lead to chronic pain, significantly impacting the quality of life of patients. Effective pain management is essential and non-invasive alternatives are highly desired. This article reviews the use of super pulsed laser (SPL) as a promising approach for the management of chronic pain secondary to burns, emphasizing the need for methods that do not induce photothermal effects, the reduction of opioid use and the search for alternative therapies. In addition, we present a clinical case that illustrates the therapeutic potential of this treatment modality.

Keywords: Burns, Chronic pain, Opioids, Sequelae of burns, SPL

1. Introduction

Burns represent one of the most prevalent types of traumatic injuries, usually accompanied by intense, persistent and often disabling pain. Data from the World Health Organization (WHO) highlights that millions of people around the world suffer burns each year, which often culminate in complications that go beyond acute pain, including the manifestation of chronic pain[1].

The incidence of burns is alarmingly high in various populations, with estimates indicating that It is the fourth prevalent injury in the world with low survival[2]. In Brazil, it is estimated that there are about one million burn-related accidents per year, of which approximately 100,000 cases require medical attention and about 2,500 people die due to direct or indirect complications of burns[1].

These accidents can be a result of various causes, such as burns, fires, chemicals and electricity. The severity of the burn is often associated with a higher risk of developing chronic pain, which can affect patients' mobility, function and mental health[2].

Studies indicate that pain resulting from burns can persist for prolonged periods, extending for months or even years. Chronic pain is a common complication in burn patients, especially due to the complexity of pain management during treatment. Research suggests that poor acute pain management may contribute to the development of chronic pain, significantly affecting patients' quality of life. It is estimated that up to 80% of burn patients describe the pain as intense and unbearable during treatment, which can lead to psychological consequences such as depression and post-traumatic stress disorder[2-4].

The indiscriminate use of opioids for pain management has become a global concern, given the growing evidence of associated risks, such as addiction and adverse health effects. This scenario has driven the investigation of innovative, less invasive therapeutic alternatives with lower risk potential. In this context, the creation of therapeutic protocols that minimize the use of opioids, through the introduction of non-invasive therapies, such as SPL, has gained prominence. This approach can reduce drug addiction and the incidence of side effects. SPL presents itself as a valuable alternative for pain management, offering efficacy without relying on opioids[4-7].

The publication of a clinical case on this therapeutic approach highlights the relevance of exploring innovative and effective alternatives that reduce opioid dependence, providing better clinical outcomes and a more humanized rehabilitation for burn patients. In addition, by integrating information from previous studies and recent clinical evidence, the review allows us to identify gaps in current knowledge, guide future research and reinforce the importance of evidence-based protocols for non-pharmacological therapies, such as SPL, in the treatment of chronic pain.

2. Literature Review

Chronic burn pain is a multifactorial condition that results from complex changes in the peripheral and central nervous systems. Initially, heat trauma causes the release of inflammatory mediators, such as prostaglandins, cytokines and bradykinins, which sensitize nociceptors in the injured area. This peripheral sensitization is accompanied by changes in nerve conduction, including hyperexcitability of primary afferent neurons and reduced activation threshold, which contributes to the persistence of pain even after the injury has healed[3,8]. In addition, disordered nerve regeneration can lead to the development of neuromas, which are additional sources of painful stimuli.

In the central nervous system, chronic burn pain is associated with central sensitization, a phenomenon characterized by increased excitability of spinal cord neurons and reduced descending inhibitory mechanisms. This process is mediated by changes in the expression of NMDA receptors and by the activation of microglia and astrocytes, which release pro-inflammatory and neurotoxic substances. The resulting synaptic plasticity contributes to the amplification of pain and the emergence of allodynia and hyperalgesia, symptoms frequently reported by burn patients[9,10]. These neurophysiological changes are exacerbated by psychological factors, such as anxiety and depression, which modulate the perception of pain and can perpetuate the cycle of suffering.

Chronic burns are affected by systemic factors like metabolic and immune changes from the hypercatabolic state caused by thermal trauma. Prolonged systemic inflammation may contribute to dysfunction of the hypothalamic-pituitary-adrenal axis, exacerbating stress response and pain perception. Recent studies also highlight the role of connections between the immune system and the nervous system in the perpetuation of chronic pain, suggesting that interventions targeting these mechanisms may offer new therapeutic perspectives[1,4]. Thus, a detailed understanding of the pathophysiology of chronic burn pain is essential for the development of more effective and individualized therapeutic approaches[11].

Traditional approaches to treating chronic pain, such as pharmacological interventions, have significant limitations that compromise their long-term effectiveness. The use of analgesics, nonsteroidal anti-inflammatory drugs and opioids, while effective in initial pain relief, is associated with a increased number of adverse effects, including dependence, tolerance, gastrointestinal and cardiovascular complications. In addition, the effectiveness of these drugs tends to decrease over time, requiring increase doses that accentuate the risk of serious side effects. Studies highlight that, despite their widespread use, these therapies often do not address the underlying mechanisms of chronic pain, limiting their ability to promote a full functional recovery[8,10,11].

Neurolysis, in turn, is an interventional technique that uses chemical agents or thermal energy to destroy the nerves responsible for transmitting pain. While this approach can provide significant relief in cases of refractory pain, it comes with considerable risk, including the possibility of permanent nerve damage, development of neuropathic pain and procedure-related complications such as infection. In addition, the efficacy of neurolysis tends to be temporary, requiring repeated procedures that increase the cumulative risk for patients[3,4]. Thus, while traditional approaches offer valuable options for pain management, their limitations underscore the importance of exploring innovative, integrative therapies that more comprehensively address the underlying mechanisms of chronic pain.

Among common interventional approaches, pulsed radiofrequency has been widely used as a minimally invasive alternative treatment for chronic pain. This technique uses high-frequency currents to modulate nerve activity without causing significant thermal damage[12-15]. Pulsed radiofrequency has been successfully applied in the treatment of various pain syndromes, such as low back pain, neck pain and trigeminal neuralgia[15,16].

The main advantage of pulsed radiofrequency is its ability to promote neuromodulation without the destruction of nerve tissue, which differentiates it from continuous radiofrequency and makes it safer for sensitive nerve structures[17-19]. Studies such as that of Shanthanna, et al, suggest that the technique acts by non-thermal mechanisms, including the modulation of inflammatory cytokines and the expression of pain-related proteins.

However, its limitations include varying efficacy among patients and the need for multiple sessions to achieve lasting results[12,13,14,21]. In addition, pulsed radiofrequency may not be effective in cases of complex neuropathic pain and there are reports of complications such as nerve injuries, infections and transient increase in pain, although these occurrences are rare and its use is off label in the USA[22,23].

According to Cosman, et al, it is a standard teaching that thermal radiofrequency should not be applied to peripheral nerves in the presence of neuropathic pain, as nerve injury resulting from heat can aggravate the clinical picture. On the other hand, pulsed radiofrequency, because it does not generate significant increases in temperature, is considered safe even in neuropathic nerves. In the cases analyzed in this study, the voltages applied ranged from 25 to 35 Voltz and, despite the low heating, the patients reported some discomfort during the introduction of the tube, which is why intravenous sedation was often necessary, a fact considered a practical limitation of the technique.

These limitations highlight the importance of careful patient selection, based on accurate diagnosis and response to previous treatments, as well as the need for standardized protocols to optimize outcomes[24,25]. The literature reinforces the role of radiofrequency as an effective tool when used in appropriate contexts and as part of a multimodal approach to the treatment of chronic pain.

Laser therapy, widely used in medicine and rehabilitation, is divided into two main types: low intensity and high intensity, both with distinct but complementary indications in certain clinical conditions. Low-level laser therapy, also known as low-intensity light therapy, acts on biochemical and cellular processes. Its mechanism is based on photo biomodulation, stimulating mitochondrial activity and promoting cell regeneration, tissue repair and inflammation relief[26-28]. It is widely indicated for musculoskeletal injuries, chronic wounds, arthritis and inflammatory conditions and is recognized for its safety and absence of significant side effects[27,29-32].

On the other hand, high-intensity laser therapy, characterized by the emission of stronger energy pulses, is used in applications that require greater tissue penetration and a more immediate clinical response. Its use is frequent in sports medicine and rehabilitation aimed at relieving intense or chronic pain[30]. However, it requires greater caution due to the associated thermal effects, which can increase the risk of complications in sensitive tissues such as burnt tissues.

It is in this context that the SPL finds its role, seeking to combine the effectiveness of high intensity with the safety inherent to low intensity. The SPL uses high-intensity pulses at ultra-short time intervals, allowing deep penetration into tissues without causing significant thermal damage[33,34]. This technology has demonstrated important benefits in the management of musculoskeletal and neuropathic pain, especially in elderly and frail populations[35-37].

Its mechanism of action involves stimulating peripheral nervous system cells and promoting microcirculation, contributing to pain reduction through the release of endorphins and inflammatory modulation.

Studies point to the safety of SPL in several clinical applications, with a low incidence of adverse effects, even in patients with chronic conditions and multiple comorbidities[27,30,31,37].

Unlike continuous or long-pulse lasers, the SPL minimizes the risk of photothermal effects, which makes it especially suitable for sensitive or damaged tissues, such as those affected by burns.

3. Case Report

Figure 1: Burn scar on patient admission.

A 58-year-old male patient was admitted in August 2024 complaining of severe pain in the infra scapularis region of the right hemithorax **(Figure 1)**. The condition began after a third-degree burn caused by an accident with an electric scalpel during heart surgery about 11 months ago. The patient had undergone previous pharmacological treatment with NSAIDs, pulse therapy with corticosteroids, opioids and gabapentin. He also underwent dermatological treatment for wound healing and analgesic blockages **(Figure 2)**.

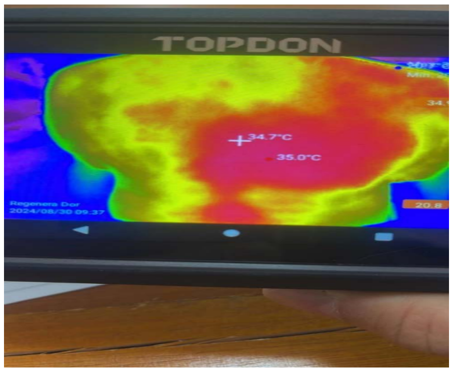

Figure 2: Thermographic image of the patient's dorsum, showing intense inflammatory response in the burn area, as well as hyper radiance in areas close to the lesion, such as the shoulder and lumbar, demonstrating hypersensitivity, changes generated by the hyperactivation of nociceptive pathways in the process of evolution and installation of chronic pain, as discussed in this article **(Figure 3)**.

The lesion progressed with improvement, but the high-intensity pain persisted, with a direct impact on sleep and preventing the patient from performing physical activities, in addition to restricting daily activities. This fact generated a negative psychological effect, with an associated depressive condition and withdrawal from their work activities. He also had mobility of the right shoulder impaired by pain. In the initial evaluation, he reported pain intensity of 9/10 on the Visual Analogue Scale (VAS), associated with a burning sensation, allodynia and local hyper radiance on thermography **(Figure 4)**.

Figure 3: Application of laser therapy according to the protocol described in the text.

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Figure 4: The patient's pain perception improved, showing reduced shoulder hyper radiance in the thermographic pattern.

A therapeutic protocol was initiated with the Multi Radiance Medical Laser Shower in super pulsed emission mode, using the Pain protocol (super pulsed emission at 1000 Hertz with wavelengths of 660nm, 875nm, 905nm with irradiation of 165 Joules per 30 cm^2) in the center of the fibro cicatricial lesion associated with the Inflammation protocol (super pulsed emission at 50 Hertz with wavelengths of 660nm, 875nm, 905nm with irradiation of 66 Joules per 30 cm^2) around the lesion. The therapy was conducted thrice weekly for three weeks.

After the second week, the patient reported a reduction in pain from 4/10 and, at the end of the treatment, he did not present any complaints of pain. In addition, there was a noticeable improvement in skin texture and desensitization of the affected area. No adverse effects were noted during or post-treatment **(Figure 5)**.

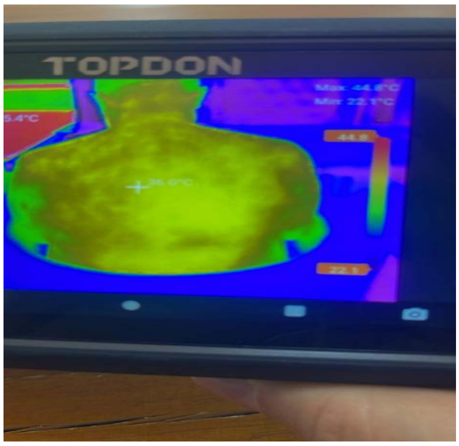

Figure 5: Absence of hyper radiance at the end of the therapeutic protocol.

4. Discussion

Burns represent one of the most prevalent types of traumatic injuries, being accompanied by intense and persistent pain. Data from the World Health Organization (WHO) highlights that millions of people around the world suffer burns each year, which often culminates in complications that go beyond acute pain, including the manifestation of chronic pain[1].

Studies indicate that pain resulting from burns can persist for prolonged periods, extending for months or even years. Chronic pain is a common complication in burn patients, especially due to the complexity of pain management during treatment. Research suggests that poor acute pain management may contribute to the development of chronic pain, significantly affecting patients' quality of life. It is estimated that up to 80% of burn patients describe the pain as intense and unbearable during treatment, which can lead to psychological consequences such as depression and post-traumatic stress disorder[3,4].

The indiscriminate use of opioids for pain management has become a global concern, given the growing evidence of associated risks, such as addiction and adverse health effects. This scenario has driven the investigation of innovative, less invasive therapeutic alternatives with low-risk potential. In this context, the creation of protocols that minimize the use of opioids, through the introduction of non-invasive therapies, such as SPL, has gained prominence. This approach can reduce drug addiction and the incidence of side effects. SPL presents itself as a valuable alternative for pain management, offering efficacy without relying on opioids[4,8,9,10].

In addition, the global opioid abuse crisis has been widely documented. Studies highlight that increased opioid use is associated with factors such as easier access to prescription painkillers and the introduction of more potent illicit compounds, such as fentanyl[8]. The approach to mitigate this crisis requires integrated strategies that consider individual, interpersonal and social factors[5-9]. At the global level, opioid abuse has generated significant economic and social impacts, including increased morbidity and mortality associated with the concomitant use of opioids and other substances[10].

The SPL an innovation in laser therapy technology, utilizes high-intensity pulses at a billionth of a second, allowing deep penetration of tissues without causing thermal damage. This characteristic makes it an ideal alternative for treating painful conditions in damaged tissues, such as burns. Its mechanism of action is differentiated by promoting the stimulation of nervous system cells and microcirculation, reducing pain through the modulation of inflammation and the release of endorphins. In addition, by minimizing photothermal risks, it prevents pain exacerbation in sensitive areas, evidencing its superiority over traditional lasers for this specific condition[34,38].

A study by Ebid, et al, demonstrated that the use of SPL in patients with chronic itch after burns resulted in a significant reduction in perceived itch, corroborating the effectiveness of this technique. Could the photo neuromodulation used to generate relief in these patients be translated into the treatment of pain? The authors emphasized the safety of the method, as there were no reports of adverse effects related to tissue heating.

The research by, Nambi et al. investigated the efficacy of gallium arsenide SPL therapy in the treatment of temporomandibular joint pain and orofacial myalgia in patients who suffered cervicofacial burns. The results showed that, after four weeks of treatment, patients who received active laser showed a significant reduction in pain intensity and frequency, as well as an improvement in mouth opening and quality of life. The research reinforces the potential of photo biomodulation as a therapeutic approach to relieve musculoskeletal pain in burn patients, offering a non-invasive and effective alternative.

Another important study by Yadav, et al. investigated the effects of SPL therapy on burn healing, focusing on bioenergetic modulation and cellular redox homeostasis. The results indicated that the application of the laser promoted a significant acceleration in the healing process, stimulating mitochondrial activity and ATP synthesis, in addition to reducing oxidative stress and inflammation. The research reinforces the potential of photo biomodulation as an effective therapeutic approach to optimize tissue regeneration in severe burns.

Chronic pain is a common complication in burn patients and poses a significant challenge for healthcare providers. The use of treatment modalities that do not exacerbate patients' pain perception, such as laser therapy and that do not cause photothermal effects, such as SPL, is crucial for effective pain management. Additionally, adopting alternative therapies instead of opioids is essential to prevent addiction and minimize its adverse consequences. In the studies reviewed and in the case presented, SPL therapy was widely accepted due to its safety and effectiveness, providing pain relief without causing additional thermal damage[27,28,30,37,40-42].

5. Conclusion

SPL therapy is an effective and safe therapeutic approach in the treatment of chronic pain secondary to burns. The absence of photothermal effects and the ability to reduce opioid requirements make this approach particularly advantageous, contributing significantly to the improvement of patients' quality of life. Future research should further explore the mechanisms involved and help establish optimized therapeutic protocols, as well as assess the durability of this therapeutic approach.

This study was carried out with the researchers' own resources, without financial support from any institution and was conducted in accordance with the ethical principles established by the Declaration of Helsinki. All participants were properly informed about the objectives and procedures of the study and provided written informed consent prior to their participation.

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