

Imaging-guided hyperstimulation analgesia in low back pain

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Abstract

Low back pain in patients with myofascial pain syndrome is characterized by painful active myofascial trigger points (ATPs) in muscles. This article reviews a novel, noninvasive modality that combines simultaneous imaging and treatment, thus taking advantage of the electrodermal information available from imaged ATPs to deliver localized neurostimulation, to stimulate peripheral nerve endings (A δ fibers) and in turn, to release endogenous endorphins. “Hyperstimulation analgesia” with localized, intense, low-rate electrical pulses applied to painful ATPs was found to be effective in 95% patients with chronic nonspecific low back pain, in a clinical validation study.

Keywords: myofascial, noninvasive, electrical, impedance

Introduction

Low back pain (LBP) is one of the most common complaints in the Western society.^{1,2} Ninety percent of the population in the United States suffer from low back pain at one or multiple points in time in their lifetime.²

Although LBP is a common chronic pain syndrome, in most cases a specific diagnosis cannot be established. It can arise due to spinal injury spinal disc problems, osteoarthritis, spinal stenosis, compression fractures, spinal tumors, etc.³

Nonsteroidal anti-inflammatory drugs (NSAIDS) are generally used for acute LBP. Opioids are the alkaloid analgesics used for the treatment of moderate to severe pain syndromes. These opioids work on the μ , κ , and α receptors in the central nervous system;⁴ however, due to the wide presence of these receptors in the body, opioids not only suppress the noxious stimuli effects, but also have undesirable side effects.^{5,6} The concerns arising from the use of analgesic medications have increased the interest in nonpharmacological therapies for LBP. Nonpharmacological treatment modalities for pain relief include heat, cold acupuncture, electrotherapy, and massage.⁷ The use of cold and hot methods has been shown to cause tissue and nerve injury.^{8–10} Among the electrotherapy modalities are transcutaneous electrical nerve stimulation (TENS) with various pulse modulation, electroacupuncture, and percutaneous electrical nerve stimulation (PENS).^{11–13}

Unfortunately, these modalities go amiss with respect to their provided duration and magnitude of analgesia. Study of TENS has produced results with limited statistical significance,¹⁴ and the American Academy of Neurology has advised against the use of TENS in chronic LBP, stating that the strongest evidence indicates that it is ineffective for this syndrome.¹⁵ One accepted explanation for LBP symptoms is that patients have myofascial pain syndrome, a condition characterized by painful active myofascial trigger points (ATPs) in muscles.^{16,17}

ATP pathophysiology

In the last 10–15 years, much clinical and basic science research into ATPs has been published, including epidemiological, diagnostic, therapeutic, and pathophysiological studies.^{17–21} The pathogenesis of ATPs is probably related to sensitized sensory peripheral free nerve endings (nociceptors) associated with dysfunctional endplates.¹⁶ In a histological study, small nerve fibers were commonly found near the sensitive ATPs.²² Therefore, the sensitive loci in the region of muscle ATPs are probably related to sensitized nerve fibers (nociceptors).

Local pain could be explained by the tissue ischemia resulting from prolonged muscle contraction, with accumulation of acids and chemicals such as serotonin, histamine, kinins, and prostaglandins.²³

Studies have suggested that the development of ATPs is dependent on an integrative mechanism in the spinal cord. When the input from the nociceptors in an original receptive field (pain from ATPs) persists, central sensitization in the spinal cord may develop, and the receptive field corresponding to the original dorsal horn neuron may be expanded (referred pain). Through this mechanism, new “satellite ATPs” may develop in the referred zone of the original ATPs.¹⁶

“Hyperstimulation analgesia” of ATPs

Common treatments of ATPs typically include minimally invasive intervention, such as injections with local anesthetics, corticosteroids, botulinum toxin, or dry needling.²⁴ Serious complications, although of rare occurrence, have been reported (eg, pneumothorax, hematoma, intravascular injection of local anesthetics, and intrathecal injections).²⁵

“Hyperstimulation analgesia” is an alternative modality, in which localized, intense, low-rate electrical pulses are applied to small surface areas at ATP locations to stimulate peripheral nerve endings (A δ fibers), thus causing the release of endogenous endorphins.^{26,27} Hyperstimulation anesthesia has been investigated in several controlled studies, showing a positive response in 87% of patients.^{26,28–30} Considerable evidence suggests that this type of neurostimulation analgesia is achieved through the activation of extra-segmental antinociceptive mechanisms, which accelerate the release of endogenous endorphins, serotonin, and cortisol.^{27,31–34}

Identification of ATPs

While the most common physical finding of ATPs has been considered the palpation of a hyper-sensitive nodule of muscle fiber of harder-than-normal consistency the identification of such nodule appears to be very dependent on the subjective experience of the physician. There is no accepted reference standard for the clinical diagnosis of ATPs, and data on the reliability of physical examination are conflicting, and a 2009 review of nine studies examining the reliability of ATP diagnosis found that physical examination could not be recommended as reliable for the diagnosis of ATPs.²⁴ Attempts to confirm the presence of myofascial trigger points using magnetic resonance elastography have been described.³⁵ Recently, Sikdar et al have tried to use ultrasound to visualize and characterize ATPs.³⁶ They found that ATPs appeared as focal, hypoechoic regions of elliptical shape, with a size of 0.16 cm.³⁶

The presence of ATPs causes a localized decrease in skin resistance compared with the surrounding area.^{37,38} The hypoxic state in the pain area increases nociceptors and other sensitizing substances in the area, and this biochemical change induces greater blood flow and secretion from sweat glands, via stimulation of the autonomic nervous system.³⁹ These physiologic differences may account for acute variations in electrodermal measurements at the pathologic site. ATPs are defined as small-diameter (3–4 mm), circumscribed low-skin-resistance areas.³⁸ Localized decrease in skin resistance is frequently associated with clinical ATPs that are richly innervated by myelinated A δ fibers^{40,41} the smallest in diameter (0.2–1.5 μ m) and most commonly present myelinated axons in peripheral nerves. Their extremely small size prevents their identification by any imaging modality³⁸

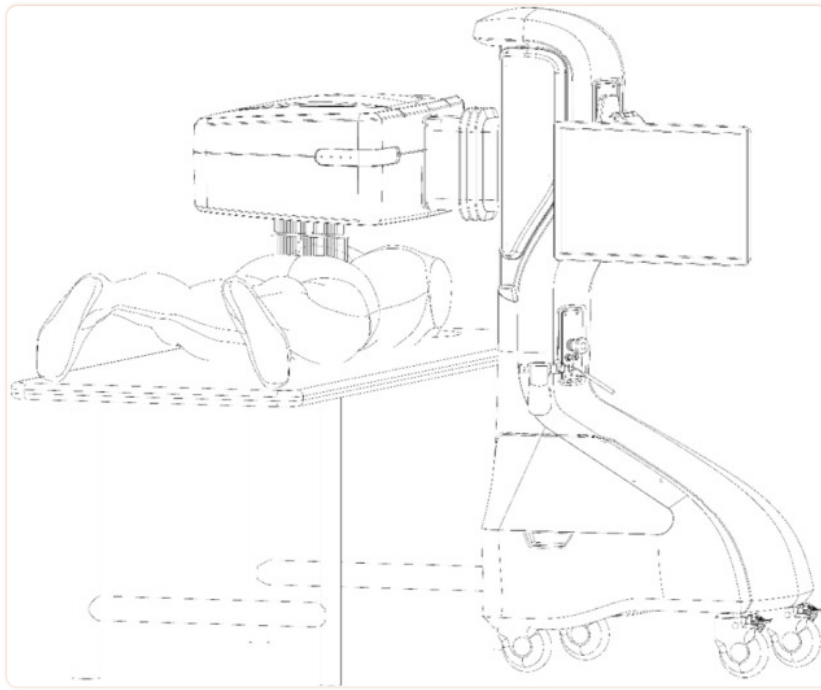
Electrical skin impedance measurements are considered to be vulnerable to certain sources of imprecision, including instrument error resulting from the size, pressure, and the duration of probe application as well as from local skin conditions, such as variable thickness, hydration, and integrity of the stratum corneum.^{38,42}

Auto-targeting hyperstimulation of painful ATPs

The hyperstimulation analgesia procedure is not extensively utilized in the clinical setting due to the necessity of locating appropriate ATPs. This necessity requires previous knowledge of the potential locations and the identification of ATPs associated with LBP and makes such treatments time consuming and cumbersome.^{26–28} Some devices offer the capability of measuring skin impedance for the location of ATPs, with the aim of applying hyperstimulation to them;⁴³ however these are manually held devices that prolong the procedure, by firstly allowing application of hyperstimulation to a single point and secondly, by offering limited accuracy (due to their measurement of a single point at a time) that does not take advantage of the electrodermal information of the entire region of interest.

A novel automated robotic system, the Soleve™ (Nervomatrix Ltd, Netanya, Israel) ([Figure 1](#)), utilizes an array of miniature probes ([Figure 2](#)), allowing the measurement of skin impedance over the back at 1000 points in less than a couple of minutes.⁴⁴ The system visualizes and analyzes the data to locate areas of low impedance compared with surrounding areas, thus indicating ATPs ap-

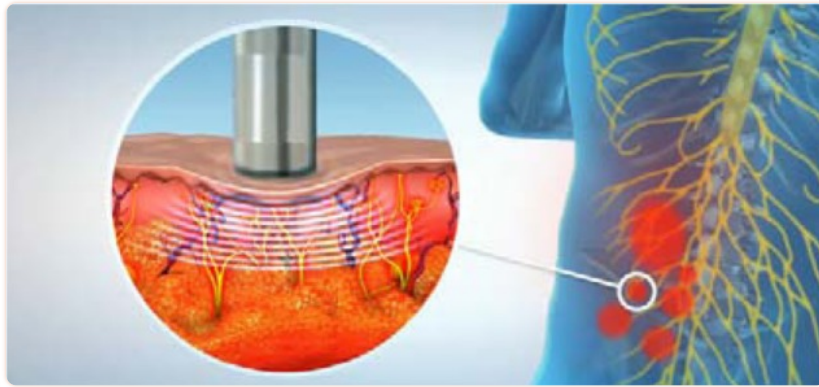
propriate for hyperstimulation ([Figure 3](#)). Therapeutic neurostimulation, using modulated, intense electrical pulses, is then applied locally to specific painful ATPs, providing highly effective pain relief by stimulating the release of endorphins.^{[31-34](#)}



[Figure 1](#)

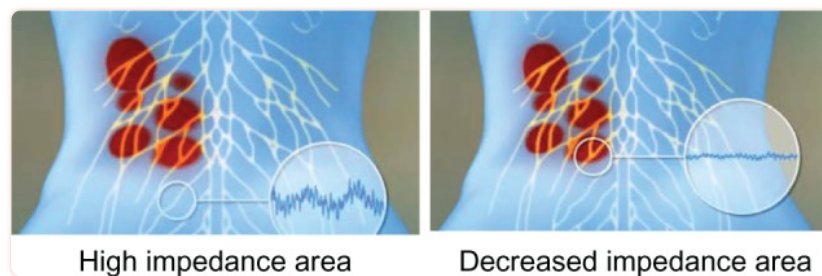
A novel automated robotic system, the Soleve™.

Notes: A moving row of 26 miniature pulsing probes gently touch but don't penetrate the skin's surface for the purposes of impedance mapping, which is then followed by the application of concentrated stimulating pulses.



[Figure 2](#)

The new modality maps the lower back by measuring the electrical resistance of the skin at 1000 points in less than a couple of minutes.

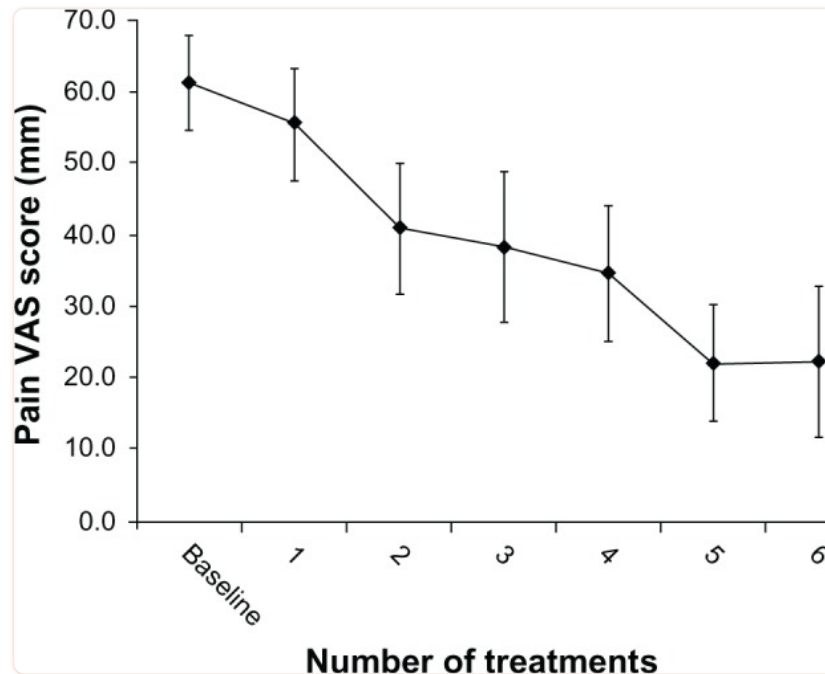


[Figure 3](#)

Computer imaging is used to analyze the data, to identify the lowest points of electrical resistance and to select the areas for therapeutic stimulation.

Clinical validation

The effectiveness of the Soleve™ system was investigated in 19 patients diagnosed with nonspecific chronic LBP.⁴⁴ Fifteen of the patients were female (79%), and four were men (21%), with a mean age of 52.1 ± 10.8 years. The protocol consisted of six treatment sessions, 2–4 days apart. Each session included a <1-minute, automatic impedance screening, followed by a 20-minute treatment. The primary outcome measurement consisted of changes in pain intensity, as measured on a 100 mm-long pain visual analog scale (VAS) obtained at enrollment, pre-, and 2 hours post-treatment. The mean $\pm$ standard deviation (SD) baseline VAS score for all patients was 61 ± 14 mm ([Figure 4](#)). Following treatment, VAS scores decreased by 39 ± 17 mm ($P < 0.001$) compared with the baseline scores. Notably, the VAS scores of all but one patient decreased by more than 20 mm after the fourth treatment, representing a marked improvement in 95% of enrolled patients.



[Figure 4](#)

Pain VAS scores.

Notes: The mean $\pm$ SD baseline VAS score for the 19 participants was 61 ± 14 mm. During treatment, the VAS scores decreased significantly compared with baseline scores, by 39 ± 17 mm ($P < 0.001$). Notably, the VAS scores of all the patients except for one decreased by more than 20 mm after the second treatment, thus showing marked improvement in 95% of enrolled patients. Courtesy from Gorenberg M, Schiff E, Schwartz K, Eizenberg E. A novel image-guided, automatic, high-intensity neurostimulation device for the treatment of nonspecific low back pain. *Pain Res Treat.* 2011;2011:152307.⁴⁴

Abbreviations: SD, standard deviation; VAS, visual analog scale.

Conclusion

A novel, noninvasive, image-guided, targeted neurostimulation modality that combines impedance imaging to locate ATPs and treatment based on the image analysis was found very effective clinically in 95% of patients after a series of four treatments. This promising result warrants future investigation and randomized, controlled, longitudinal studies in the treatment of LBP.

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Footnotes

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