

Nonpharmacologic Treatment of Neuropathic Pain Using Frequency Specific Microcurrent

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Frequency-specific microcurrent (FSM) has been used for 10 years by numerous practitioners in various specialties (MDs, DCs, NDs, PTs) to treat myofascial pain and neuropathic pain in clinical practice (1-3). This retrospective analysis of patients treated for neuropathic pain in the author's clinic presents a collected case report in patients treated for monoradicular pain, in an effort to quantify the results produced with FSM treatment of neuropathic pain. The proposed mechanisms of peripheral neuropathic pain will be compared with the data associated with dual-channel, frequency-modulated microamperage current to suggest a model for how frequency-modulated microamperage current could be producing the observed results. Central neuropathic pain from postthalamic stroke and phantom limb pain, and peripheral diabetic neuropathies have been successfully treated using this method, but those types of neuropathic pain were excluded from this analysis.

Neuropathic Pain and Cytokines

FSM has been shown to reduce inflammatory cytokines while treating the pain of fibromyalgia associated with spine trauma. In fibromyalgia associated with spine trauma, patellar reflexes are hyperactive, there is specific dermatomal hyperesthesia in addition to the allodynia characteristic of central sensitization, and opioids are not effective; all of which suggest pain of neuropathic origin. One specific frequency combination, 40 Hz on one channel and 10 Hz on the second channel delivered simultaneously using polarized positive direct current, has been shown to reduce IL-1 (330 to 80pg/ml, $p=0.004$), IL-6 (239 to 76pg/ml, $p=.0008$), TNF α (305 to 78, $p=.002$), and substance P (180 to 54pg/ml $p=.0001$), and to increase endorphins (8.2 to 71.1pg/ml, $p=.003$). Pain scores were reduced from an average of 7.3 ± 1.2 to

1.3 ± 1.1 in 45 patients ($p=.0001$). No other frequency combination reduced pain in this patient population. This frequency combination is not effective in patients whose fibromyalgia onset is not associated with spine trauma and whose reflexes and dermatomal sensation are normal. Fifty-eight percent of patients treated with this protocol recovered from fibromyalgia within 4 months (4).

Neuropathic Pain and Prostaglandins

Studies have shown an association between the induction of COX-2 increased prostaglandin release and enhanced nociception in neuropathic pain. Expression of COX-1 and COX-2 in primary afferents and in the spinal cord suggests that NSAIDs act there by inhibiting synthesis of prostaglandins (5-7).

A study in a mouse model used arachidonic acid-induced lipooxygenase (LOX)- mediated inflammation to create measurable swelling in mouse ears. This blinded trial demonstrated a 62% reduction in ear swelling in all animals treated with FSM using 40Hz on one channel and 116Hz on the second channel when compared with sham and the untreated controls. This was a time-dependent response with half of the effect present at 2 minutes and the complete effect present at 4 minutes. Additional treatment time provided no additional reduction in swelling. Three different 2-channel frequency combinations tested in the same mouse model produced no reduction in swelling and were equivalent to sham treatment. The unsuccessful combinations were 294 Hz and 62 Hz, 91 Hz, and 59 Hz, 0.3 Hz on both channels. The author concluded that FSM experimentation demonstrated the result to be reproducible, application time-dependent, and specific. Other FSM frequencies had no effect on the model (8).

Neuropathic Pain and Sodium Channels

The sodium channels in damaged nerves demonstrate different depolarization characteristics than do undamaged nerves (1,6). Following injury to their axons, DRG neurons downregulate some sodium channel genes and upregulate others, causing a different assortment of sodium channels to be inserted into the DRG following injury. The modified sodium channels have modified properties that contribute to hyperexcitability in the DRG, increased pain transmission, and sensitization (11).

There are several mechanisms by which current and the voltage that drives it could influence voltage-gated ion channels (VGICs) and sodium channels (VGSCs). The battery-operated devices used in treatment put out pulsed direct (DC) current. The frequencies delivered are not pure sine wave frequencies, but rather square wave pulses. Single channel, single frequency micro-amperage current used alone on neuropathic pain did not demonstrate any palliative or curative effect. However, the current must have had some contribution to the observed effects, because trial and error demonstrated that the treatments for neuropathic pain are only effective if the positive contact is placed on the spine at the point where the nerve exits and the negative contact is placed at the distal end of the nerve to be treated and the current is polarized positive. The devices can output either alternating square wave pulses or polarized positive or negative square wave pulses. Only polarized positive pulses have been observed to reduce neuropathic pain. Other types of pain, such as myofascial pain from trigger points and delayed onset muscle soreness, have been reduced with square wave pulses of alternating DC current (1,2,10).

Cheng and associates demonstrated that applying additional current to a biological system increases both protein synthesis and energy production dramatically, as long as the current was small enough. Direct current levels of 50 to 1,000 μ amps applied across rat skin increased glycine (amino acid) transport by 75% compared with untreated controls and current levels of 500 μ amps increased aminoisobutyric acid (amino acid) uptake by 90%, indicating a dramatic increase in protein synthesis. Current levels above 1,000 μ amps decreased protein synthesis by as much as 50% (11).

Adenosine triphosphate (ATP) is the chemical energy molecule that fuels most mammalian biological processes. Direct current levels between 100 and 500 μ amps applied to rat skin increased ATP levels by 3 to 5 times (300% to 500%). Current exceeding 1,000 μ amps caused ATP

production to level off, and currents above 5,000 μ amps reduced ATP levels as compared to untreated controls. Once the external current was discontinued, ATP production and amino acid transport levels returned to baseline; there was no residual effect in rat skin (11). This study has not been replicated in vivo or in humans.

The microcurrent devices used in treating neuropathic pain are constant-current generators that increase the voltage up to 30 volts as needed to maintain the current levels set on the device. It has been proposed that VGICs in cell and neural membranes may be affected by the current and voltage flowing along or across the membrane, but no one has measured changes in these transport proteins in response to externally applied microamperage current. VGICs require ATP activation to change configuration allowing them to transport ions across the cell membrane. If the current affects VGIC function, it may do so simply by increasing ATP production. While it is clear that current flow has an effect on neuropathic pain, the exact mechanism needs to be clarified.

Collected Case Report

Methods

Seventy-seven patients were selected for review from pain clinic charts according to their diagnostic code indicating neuropathic pain. Patients included in this paper had sensory examinations and reflexes altered from normal and a mechanism of injury that could reasonably have caused neuropathic pain. Patients who did not have pretreatment and posttreatment data for every visit, or who met criteria for other diagnoses (eg, fibromyalgia, diabetic peripheral neuropathy, postherpetic neuralgia) were excluded. Twenty patients met criteria and were included in the analyses. Sixteen (80%) were females and 4 (20%) were males. The average age was 47.70 (SD=11.19, range 24 to 68).

Treatment Method

FSM can be applied using any 2-channel microamperage current device that can provide frequency pulses accurate to 3 digits on 2 channels simultaneously using alternating or polarized positive DC current with a ramped square wave pulse. Two different devices were used to deliver treatments. The Precision Micro (Precision Microcurrent, Newberg, Oregon), an analog, battery-operated 2-channel, 3-digit-specific microcurrent device was used for some

treatment sessions. This device requires frequencies on both channels to be set and changed manually. The AutoCare, or AutoCare Plus (Microcurrent Technologies, Seattle, Washington) was used during some treatments. These are digital, battery-operated, 2-channel, 3-digit-specific microcurrent devices preprogrammed to run certain specific frequency combinations for various time periods. They include the protocols for treating neuropathic pain.

Patients must be adequately hydrated for the treatment to be effective. In general, patients were instructed to drink 1 to 2 quarts of water in the 3 to 4 hours before treatment. For treatment, the patients were placed in a comfortable, supported position appropriate to the nerve root being treated. The graphite glove electrodes were wrapped in a warm, wet hand towel to allow broad flexible skin coverage and good conductivity (Figure 1). The positive contact was placed at the point on the spine where the nerve exits. The negative contact was placed at the distal end of the nerve to be treated and the current was polarized positive. The frequencies observed to reduce pain were 40Hz on one channel and 396 Hz on the second channel. The pain begins dropping in minutes and declines in a time-dependent fashion over 30 minutes, requiring a maximum of 60 minutes to reach optimal benefit. Treatment beyond 60 minutes did not produce any additional improvement.



Figure 1. Positive leads are placed where the treated nerve exits the spine. Negative leads are placed at the end of the dermatome. The leads are connected to graphite gloves and the graphite gloves are wrapped in a warm, wet contact to allow coverage and convenient placement. This placement treats the C5-C6-C7-C8 nerve roots.

Once the pain was reduced, attempts to return to full range of motion were observed to create pain or sensations of pulling or aching in the affected nerve root. Adhesions between nerves and the surrounding fascia and between the nerve, cord, and dura are known to cause pain and limit range of motion (11,12). Burn patients with mature scarring were treated with certain frequency

combinations and experienced lasting increases in range of motion (13). Postradiation scarring was modified and range of motion increased by use of an impedance-controlled, frequency-modulated microcurrent device (14).



Figure 2. When the pain is reduced and range of motion is still restricted, the frequencies are set to 13Hz and 396Hz, and the affected nerve root and limb are moved gently through range of motion. When the patient reports pressure or discomfort, the limb is returned to neutral while the current and frequency continue to treat. The range is tested again and usually increases with each attempt. Normal range is usually achieved within 15 minutes.

Trial and error showed that if the patient was treated with the frequencies 13Hz on one channel and 396 Hz on the second channel while moving the limb (and nerve) to edge of the range, within the limits of comfort, the range of motion would return to normal within 10 to 15 minutes. Only this frequency combination was useful for increasing range of motion (Figure 2). The 40Hz and 396Hz combination had no effect on increasing range of motion and was useful only for reducing pain. 13Hz and 396 Hz had no effect on reducing pain and were useful only for increasing range.

In general, patients were treated twice weekly. Low-velocity spinal manipulation was used after the microcurrent treatment in some, but not all patients.

Side Effects

No patients reported or complained of side effects either during or after treatment. The most common side effect is a sensation of euphoria, presumably created by increases in endorphins, such as those seen in the fibromyalgia patients (8). It was not uncommon for patients to fall asleep during the first treatment, but no patient complained about this euphoric effect. Patients were kept in the clinic after treatment until they returned to normal and they were considered safe to drive.

If patients have bony foraminal or spinal cord stenosis, the current and treatment protocol may cause a temporary increase in pain that resolves over 24 hours when the treatment is stopped. No increase in pain was observed in any of the patients in this analysis.

Results

The chronicity of neuropathic pain varied from 1 week to 44 years, with a mean of 6.69 years (SD=10.72). Patients received an average of 4.60 treatments, with a range from 1 to 15 (SD=3.75) treatments. The primary mechanism of pain most commonly reported was a disc injury (65%, n=13). Other mechanisms included traction injuries (n=2), falls (n=1), other (n=1), and unknown (n=1). Eleven patients had more than one mechanism of onset. Of those, 7 (35%) indicated a motor vehicle accident as the onset. No patient in this group had a lawsuit pending related to an accident. In general, patients with disc injuries required the greatest number of treatments; patients with traction injuries required the fewest number of treatments.

Table 1 provides the means and standard deviations for pretreatment and posttreatment pain scores for treatments 1 through 4. The Wilcoxon Signed Ranks Test was employed to compare patients' pretreatment and posttreatment pain scores. Since the average number of treatments was 4.60, and 6 or fewer patients completed treatment 5 and beyond, analyses were completed only for treatments 1 through 4.

For treatment 1, the average initial pain score was 6.78 / 10 (SD= 1.80), with a range of 4 to 10. The average pain score at the end of the first treatment was 1.83 / 10 (SD=2.10), with a range from 0 to 8. Even with the outlier whose pain was reduced only from 10/10 to 8/10, the posttreatment pain scores were significantly lower than pretreatment scores with $Z = -3.83$ and $p < 0.001$.

For treatment 2, the mean pretreatment pain score was 4.75 / 10 (+/- 2.60) and the mean posttreatment score was 0.97/ 10 (SD = 1.6). The posttreatment pain scores were significantly lower than pretreatment scores with $Z = -3.63$ and $p < 0.001$.

For treatment 3, the mean pretreatment pain score was 5.14/10 (SD = 1.99) and the mean posttreatment pain score was 0.46 / 10 (SD = 0.84). Posttreatment scores were significantly lower than pretreatment scores, with $Z = -3.30$ and $p < 0.01$.

For treatment 4, the mean pretreatment score was 3.94/10 (1.96) and the mean posttreatment score was 0.29/10 (SD = 0.76). The posttreatment scores were significantly lower, with $Z = -2.37$, and $p < 0.05$.

Of the 20 patients reviewed, 65% (n=13) fully recovered from nerve pain. Twenty-five percent terminated care before recovery (n=5) for reasons not associated with the treatment. One patient was referred for additional treatment by epidural steroid injection. One patient purchased a small automated microcurrent unit for home use while her disc injury healed.

Discussion

This retrospective analysis of a typical assortment of chronic neuropathic pain patients attempts to quantify the anecdotal reports of successful treatment of chronic neuropathic pain using frequency-specific microcurrent. Patients improve most dramatically during the first 4 treatments. Patients with traction injuries usually recover within 2 to 3 treatments. Patients with disc injuries and ligamentous laxity, especially in the cervical spine, require the greatest number of treatments because the discs and ligaments that are perpetuating the neuropathic pain need time, spinal stabilization exercises, and other forms of physical therapy to heal.

All patients reported some reduction in pain with treatment. The patients who terminated care did so even after treatment had reduced pain and did so for reasons not related to treatment side effects such as cost, travel time, and other personal situations.

Only the frequencies 40 Hz on one channel and 396 Hz on the other channel reduced pain. Only the frequencies 13 Hz on one channel and 396 Hz on the other channel increased range of motion.

As seen in the mouse trial and the fibromyalgia patients, patient response to the current and frequency combinations to reduce nerve pain were time dependent (8,10). Thirty to 60 minutes of treatment were required to reduce pain from an average of 6.78/10 to an average

Table 1

Treatment # (n)	Pre-Tx Mean (SD)	Pre-Tx Range	Post-Tx Mean (SD)	Post-Tx Range
Treatment 1 (n=20)	6.78 (1.80)	4-10	1.83 (2.10)	0-8
Treatment 2 (n=17)	4.75 (2.56)	2-10	0.97 (1.60)	0-4
Treatment 3 (n=14)	5.14(1.99)	1-8	0.46 (.84)	0-2
Treatment 4 (n=7)	3.94 (1.96)	2-8	0.29 (.76)	0-2

of 1.83 /10 on a 0-10 VAS scale on the first treatment. Approximately 30 minutes of treatment were required to reduce pain from 4.75/10 to 0.97/10 for the second treatment. At the 15-minute mark, approximately half of the eventual effect was present.

The 30- to 60-minute treatment time required to reduce neuropathic pain corresponds to the time-dependent response seen in the mouse anti-inflammatory research. In the mice, half of the effect was produced in 2 minutes and the full effect was seen at 4 minutes. Additional treatment time beyond 4 minutes did not produce any additional effect (8).

In neuropathic pain in humans, the pain begins to be reduced within a 15-minute treatment time, but 30 to 60 minutes are required to create optimal lasting reductions in pain. The frequencies to increase range of motion have their effect more quickly than those to reduce inflammation and pain but are still time dependent. The frequency must be used for 10 to 15 minutes in combination with movement to produce an optimal increase in range of motion.

Conclusion

Dual channel, specific-frequency microamperage current produced dramatic improvements in a collected case report of patients with chronic neuropathic pain. Treatment is noninvasive, low risk, widely available, relatively inexpensive, and appears to have no significant side effects. A controlled trial should be performed to further evaluate its effectiveness in this otherwise difficult patient group. ■



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