Contemporary Acupuncture and movement disorders: strategies to restoring sensory-motor function

Alejandro Elorriaga Claraco, MD, Sports Medicine Specialist (Spain)
Director McMaster Contemporary Medical Acupuncture Program

Introduction

In the last three decades, experimental research on acupuncture mechanisms and effects have provided the basis to re-defining this old therapy as a form of peripheral nerve stimulation. The term Contemporary Acupuncture is rapidly becoming the international choice of practitioners using a biomedical approach in counter distinction to traditional acupuncture approaches.

Contemporary acupuncture is defined as a therapeutic method in which fine solid needles are inserted on neuro-reactive sites of the body, for the purpose of inducing central, autonomic, and/or somatic (motor and sensory) neuromodulatory responses.

Neuromodulation is the intrinsic property of the nervous system to regulate its own activity in response to exogenous or endogenous stimuli, e.g. exposure to a cold environment produces reflex vasoconstriction of the skin vessels, contraction of a muscle produces a reflex relaxation of its antagonist, etc.

Control of movement is one of the most complex tasks of the somatic nervous system and involves several well known reflex neuromodulatory responses; contemporary acupuncture has proven to be effective in the modulation of some of these reflex responses as it will be discussed later in this article.

Neuroreactive sites

A neuro-reactive site is any area of the body where there is somatic and/or autonomic innervation. Somatic nerve fibers are those—within spinal and peripheral nerves—that innervate the muscles, joints and skin. On the musculoskeletal system, sympathetic nerves fibers can be found associated to the arterial network, as well as travelling with the somatic nerves.

Somatic motor axons are always myelinated and are classified functionally on the basis of their mean conduction velocity into three categories—A-α, A-β, and A-γ—each one innervating different striated muscle fibers, i.e. extrafusal (A-α), intrafusal (A-γ), and both (A-β).

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Somatic sensory axons are classified functionally into four types (I to IV) also on the basis of speed of conduction. Within the muscle-tendon-joint region, sensory axons innervate a variety of specialized sensory receptors, i.e. muscle spindles (Ia, II), Golgi tendon organs (Ib), ligament receptors (Ib), Paciniform and Ruffini's receptors in joint capsules (II), muscle deep pressure endings (III), and muscle free nerve endings (III, IV).

Some of these categories of axons are also found in the skin and fascia. The fascia is particularly rich in sensory innervation with Pacinian corpuscles, Ruffini organs, small myelinated free nerve endings (A-δ fibers or mechano-nociceptors), and unmyelinated free nerve endings (C fibers also able to transmit pain and mechanical signals such as very gentle pressure and tension).

This rich variety of skin, fascial, and musculoskeletal somatic afferent fibers carrying exteroceptive information (pain, touch, temperature) and proprioceptive information (position sense, joint movement, muscle length, rate of change of muscle length, muscle stretch, tendon tension, ligament tension) explains the vast number of neuro-reactive sites available for acupuncture stimulation.

From the neurofunctional standpoint described above, each potential acupuncture stimulation site (or neuroreactive site) is just a combination of different nerve fibers and their receptors. The potential effects of stimulating a given site will depend on the type of nerve fiber responding to the specific stimulus provided by the needle insertion.

Afferent activity on peripheral nerves is fiber specific, and each nerve fiber is only responsive to a specific quality of stimulus provided at sufficient intensity. For instance, a high temperature stimulus will not trigger depolarization of low threshold pressure receptors.

Consequently, the specific neuroanatomy of an insertion site (the type of nerve endings and receptors in the area) and the quality of the mechanical and electrical stimulation of the needle position into that tissue, are the neurofunctional factors determining the local, segmental and supraspinal responses triggered by the intervention.

If the nervous system had suffered physiological or pathological changes, then the response to acupuncture stimulation will be affected accordingly by those changes.

Best neuroreactive sites for acupuncture stimulation

The anatomical and functional picture described above explains why, despite the abundance of potential insertion sites available for peripheral nerve stimulation, the most effective neuro-reactive sites for acupuncture stimulation are those associated with the areas of the musculoskeletal system where the somatic

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sensory and motor innervation is particularly rich, i.e. muscle belly, muscle-tendon junction, tenoperiosteal attachment, periosteum, joint capsule, ligaments, neurovascular bundles, neuromuscular junctions or motor points, and the omnipresent fascia.

As a corolary, it is easy to understand why contemporary acupuncture can be extremely effective in the treatment of movement disorders by virtue of stimulating relevant sensory and motor somatic receptors, therefore helping restore normal sensory-motor activity in the treated segment.

Unfortunately, most current acupuncture research efforts are focusing on the applications of acupuncture for the treatment of pain, while in the opinion of the author of this article the use of acupuncture as a segmental and regional sensory-motor regulatory intervention could play in the near future a fundamental role in the area of treatment of movement disorders.

Movement, proprioception, and subconscious stimulation

It is well known but often forgotten that most proprioceptive information is processed without conscious participation of the individual. One important practical implication of this point is that in order for acupuncture to stimulate proprioceptive receptors the intensity of the stimulus can be very low and its conscious perception is not necessary.

It is also frequently forgotten that fully normal proprioception requires participation of muscle spindles, joint receptors, and cutaneous mechanoreceptors. This redundance probably reflects the importance of proprioception to the control of movement. People with total hip replacement retain good proprioception in midrange. This indicates that joint receptors are not essential for proprioception.

From a contemporary acupuncture practical standpoint, it is paramount to understand the importance of painless needle insertion, with slow and painless advance of the needle through the different layers of tissue, since every layer of tissue (skin, fascia, muscle, and joint) is a potential contributor to the global proprioceptive message.

Obviously, there are a variety of neurophysiological strategies involved in movement control, but to better appreciate the potential role of contemporary acupuncture in the treatment of movement disorders, we can simply divide them from an anatomical standpoint into segmental, intersegmental, and supraspinal. Not uncommonly, the nervous system uses a combination of all of these when dealing with movement control. For instance, the activity of gamma motorneurons is regulated primarily by intersegmental and supraspinal pathways and little by segmental sensory inputs, while the autogenous inhibition reflex mediated by the Golgi tendon organs is mainly segmental in nature.

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In general, a great deal of proprioceptive information related to the control of movement in a given area is processed segmentally and intersegmentally, such as the reciprocal inhibition and autogenous inhibition reflexes.

Summary of contemporary acupuncture effects relevant on the management of movement disorders

Physiological response to contemporary acupuncture interventions include: segmental and systemic analgesia, neuromodulation of sensory, motor, autonomic and visceral functions, modulation of endocrine and immune functions, and modulation of central functions such as those associated with the activities of the limbic system.

Since the purpose of this article is to focus on the effects of contemporary acupuncture on the modulation of relevant sensory and motor functions of the musculoskeletal system, a summary of relevant effects follows.

The main set of segmental effects involves motor, sensory, and autonomic dimensions at the spinal level, putting the three kinds of “gate controls” into action, with results such as:

1) modulation of the transmission of signals in nociceptive and other sensory afferent fibres (spinal gate control of the sensory afferent system)
2) normalisation of segmental muscular tonus and functionality (spinal gate control of the locomotor system)
3) normalisation of segmental sympathetic and parasympathetic activity (spinal gate control of the autonomic nervous system)

Spinal gate control of the sensory afferent system

All kinds of somesthetic inputs to the spinal cord, both protopathic sensations (such as nociception) and epicritic (such as proprioceptive afferents) are modulated at the metameric level.

In the case of pain, the activation of myelinic sensory fibres (nociceptive or not) modulates the activity of the nociceptive fibres, a process that result in clinical improvement of pain and local pain-related alterations, and sensory function normalization.

Spinal gate control of locomotor system (sensory-motor integration)

In contrast to the mechanisms that cause and sustain motor dysfunction, whether inhibition or hyperactivity, the motor gate control activation promotes restoration of spinal segmental sensory-motor integration which results in restoration of normal motor activation of the muscles innervated by the segment, as well as modulation of muscle and tendon proprioception.

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Spinal gate control of the autonomic nervous system

The modulation of segmental autonomic system activity generates consequences that include the treatment of regional autonomic components of pain. It plays an important role in the restoration of the regional functional normality, especially of the circulatory segment, and in the reduction of one of the main factors that perpetuates regional chronic pain – the sympathetic hyperactivity.

It is easy to see how the interaction of these three spinal gate control mechanisms will help normalize sensory-motor integration at the affected segment and in the adjacent ones, with normalization of vasomotor tone and improved perfusion of the affected tissues locally.

To accomplish these effects needles can be inserted both at the peripheral segmental level on the affected muscles and joints or their relevant nerves, or on the paravertebral musculature also at the relevant segmental somatic (dermatome, myotome, sclerotome) and segmental autonomic levels (reflex vascular areas).

Mid range and high frequencies (15-20 Hz and up) reinforce the segmental effects of these inputs, while low frequencies (2-4 Hz) engage supraspinal mechanisms in the neuromodulation of the segmental and intersegmental activities.

Contemporary acupuncture in the treatment of movement disorders: the chronic functional ankle instability model

Some of the strategies of contemporary acupuncture in the treatment of movement disorders can be exemplified by the treatment of chronic functional ankle instability.

It is well known that individuals with this conditions exhibit important motor deficits in the absence of significant structural problems, with a clinical picture of repeated episodes of giving way, decreased strength of periarticular muscles, and decreased proprioception and balance.

Recently, a pilot study showed that in these individuals, a single session of electro-stimulation of two needles—one inserted into the sinus tarsi and the other on the proximal aspect of the peroneus longus muscle at the level of the fibular neck (right by the trunk of the common peroneal nerve)—produced significant changes in strength, proprioception, balance, perceived discomfort, and the number of reported episodes of giving way, with all the improvements still remaining one month post treatment.

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The only explanation for this spectacular clinical improvement is the segmental normalization of sensory-motor activity with elimination of the prior regional motor inhibition. This is consistent with contemporary concepts on the pathophysiology of this condition. Namely, that the presence of abnormal signals from the interosseus talo-calcaneal ligament produces a segmental motor inhibition of the movers of the subtalar joint. This motor inhibition is reversible with an injection of local anesthetic into the sinus tarsi. Strength remains as long as the effect of the local anesthetic does. Objective changes on EMG activity of the peroneal muscles have been reported after these anesthetic injections into the sinus tarsi. Unfortunately, these changes revert once the anesthetic effect is over.

So, it seems that acupuncture can somehow override abnormal sensory signals and produce normalization of segmental activity which will result in normalization of motor activity and normalization of sensory-motor integration in the region.

These experimental results validate some of the acupuncture approaches used empirically on the treatment of movement disorders.

Contemporary acupuncture selection of inputs in movement disorders: final thoughts

As a summary of the contemporary acupuncture strategies discussed in this article, when dealing with movement disorders:

1) identify the affected joint or joints using clinical history and range of motion;
2) identify weak muscles—agonists, antagonists, or stabilizers—using motor testing; identify tight muscles;
3) determine abnormal recruitment patterns;
4) identify the associated spinal segmental levels of dysfunction using the affected peripheral dermatome, myotome, and sclerotome as the guiding neurofunctional units;
5) identify central factors;

Generate specific contemporary acupuncture inputs using these strategies:

- treat agonists and antagonists involved
- treat joints involved
- treat motor and sensory nerves involved
- treat spinal segments involved

The discussion of the technical aspects involved in each of these strategies is beyond the scope of this article, but the anatomical and functional basis of the model have been explained early on this article. The ultimate key is to select the most relevant neurological receptors and pathways involved in the presenting dysfunction.

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