MICROCURRENT THERAPY

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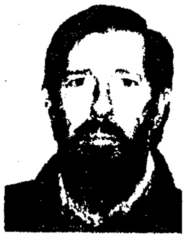
Editorial Comment

Recent interest in the technical aspects of microampere theories suggested inclusion of this article at this time. Our readers should contact the authors for further details and data.



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MicroCurrent Therapy (MCT) has arrived on the scene at an opportune time to help health care professionals in their quest for more cost-effective patient treatment techniques. The wide range of soft tissue dysfunctions being addressed by this noninvasive, nonpharmaceutical modality suits it ideally to physical therapy.

Microcurrent first gained popularity in treatment of wounds, nonunion fractures, and bone implants, where it has become an accepted procedure with orthopedic surgeons and physical therapists (6, 8, 20). More recently, MCT has been applied with success to spasm, inflammation, edema, connective tissue problems, etc. (19). Fortunately, relatively inexpensive, state-of-the-art MCT devices are available so that practitioners can explore their virtues readily.

A basic definition of MCT is introduction of a small electrical current into the body to achieve a therapeutic effect. However, there is far more to this concept than just using lower current (millionths instead of thousandths of an ampere). Electrical stimulation involves two primary systems—the bioelectric stimulator and the biosystem (patient) to which this device is applied. In the case of the stimulator, there are only three variables: waveform, intensity, and frequency. Many more variables characterize the patient. For example, capacitances of skin and combinations of soft and connective tissue, fluid, and bone all depend not only on constituent materials, but also on stimulator waveform frequency. Interactions between all such variables determine the relative effectiveness of a given bioelectrical stimulator when used for treating a specific dysfunction.

There are two dominant considerations in patient treatments:

1. The patient's perception of treatment comfort.
2. The patient's and the practitioner's perceptions of treatment effectiveness.

State-of-the-art MCT devices utilize combinations of low voltage, low frequency, and unique waveforms such that treatments are essentially subsensory. Even the two most popular EMS concepts, high voltage and interferential, are decidedly sensory.

When considering the output parameters of these different concepts, it becomes obvious that MCT does not supply sufficient electrical energy to provide neural stimulation, whereas conventional EMS devices do. There simply is not enough current involved in this concept to develop action potentials in excitable tissue. Therefore, the acronym MENS, commonly used to describe MCT, is not only inaccurate but, also, misleading. We must look to mechanisms other than neural stimulation to explain how MCT works.

Most of the published research on the effects of microcurrents on soft tissue injury have described the accelerated healing of ulcers in the skin and associated suppression of bacterial growth (2, 9, 11, 20). A skin ulcer is an injury that is visible and easy to assess. The rate of healing can be gauged by measuring the size of the ulcer, and bacterial samples are obtained easily with a swab. There is now substantial evidence from laboratory studies that microcurrent enhances cell multiplication in connective tissue, also speeding formation of new collagen in injured tendons and helping to increase strength in healed tendons (1, 17). Accelerated healing of ligament and tendon injuries has been reported by the physician of a Canadian olympic team (17). By routinely using MCT, he reduced recovery time to one-third that normally experienced by athletes with anterior cruciate ligament and achilles tendon problems. Also, there is evidence that MCT can cause a substantial and long-lasting reduction in chronic back pain (13).

Bioelectricity, Tissue Regeneration, and Healing

Much of what we know about electrical currents in the body comes from the work of Robert Becker (4). He spent many years studying regeneration in the salamander and other animals, and as an orthopedic surgeon, pioneered the methods used today for treating non-union fractures. Microcurrents were first seen at amputation sights and in conjunction with other injuries. Becker called these "currents of injury" or "stump currents." These electrical currents at injury sites were associated with the animals' abilities to regenerate damaged or lost limbs. The greater the current density, the more complete the regeneration. This helped explain the differences between various types of animals in their regenerative abilities. Many animals, especially when young, can regenerate lost limbs or portions thereof. The most proficient in this function is the salamander, which coincidentally has the greatest injury current density of all land animals.

Becker's most astonishing discovery was that, under the influence of an appropriately applied direct current, certain cells are capable of dedifferentiation. He found that, in frogs, mature, fully differentiated cells are able to retrogress to an embryonic form, then redifferentiate into whatever cell types are needed for complete regeneration.

In the case of human beings, there is the question as to whether microcurrent is effective through a regeneration or a healing process. This is a very significant distinction. Healing involves mature, fully differentiated cells multiplying and building new tissue as fibroblasts lay down collagen or as epithelial cells migrate over an open wound. Regeneration is the dedifferentiation, or regression of cells to a more primitive form, and their subsequent redifferentiation into cells of complex tissues and organs. Also, it is possible that existing primitive cells differentiate into these more complex forms. Although regeneration occurs naturally in salamanders, can be induced in frogs, and has been seen in very young mammals (including human children), solid evidence is lacking as to true regeneration in adult mammals.

> *We must enter the shadowy world of cell molecular biology to address the issue of how cells respond to electric currents in a way that increases their healing activity!*

Both Becker (4) and Nordenstrom verified that the body continuously generates low-level direct currents during healing (18). At first glance, it might appear that conduction of these currents is through the electrolyte solution present everywhere in the body. However, although ionic solutions do conduct electricity, ions are large, slow-moving particles, and an ionic current dissipates in a very short distance. Ionic currents are very influential across cell membranes, but they are not suited to long-distance transmission.

Although nerve signals, which are electrochemical events, are transmitted over large distances in the body, we cannot assume that electrical currents use the same channels. However, there is a vastly greater network of cells that supports and nurtures the neurons. These are the glial cells in the central nervous system and Schwann cells in the peripheral nerves. Neuron cell bodies reside in the brain and spinal cord, their axons and dendrites extending outward to form the peripheral nerves that connect every part of the body to the CNS. The glial and Schwann cells are electrical conductors that do not transmit discrete signals like neurons, but rather carry very small direct currents. These currents may have a profound effect, either directly or through the magnetic fields they generate, not only on the neurons which they surround, but also on the cells.

Another possible conductor of electricity is the circulatory system, particularly the capillaries. Nordenstrom has found that in an area of injury a positive charge builds up, which seems to serve as an electrical sink and attracts negative current flow (18). Concentration of the injury current is enhanced further by the ability of the circulatory system (capillaries) to conduct electricity. This happens when the normally ion-permeable walls of the capillaries become less so in dysfunction, forcing an increased current flow through these channels to the point of injury. Nordenstrom has had some very positive results in causing lung tumors to regress by using electrical currents (18).

Even more interesting is the idea that collagen, the most common protein in the animal kingdom, may behave as a semiconductor. A semiconductor is a material that offers very low resistance to small currents, thus permitting their ready transmission. Conversely, a semiconductor opposes transmission of large currents with very high resistance. Semiconductors are usually crystals, and the collagen in many structures has crystalline properties. Collagen under stress will generate small electrical potentials in the same way that bone does (piezoelectric effect). As a semiconductor medium, collagen could be the network that carries small currents all over the body.

Then there is that biological "will-o-the wisp," the meridian. The functional existence of meridians is a basic tenet of Chinese medicine. Their physical existence has been demonstrated by the use of radioactive tracers injected at acupuncture points (12). Although the tracers distributed along the meridians, their anatomical nature remains in dispute. The Korean investigator, Kim Bong Han has claimed histological demonstration, but so far his results have not been reproduced (12). Meridians also have been shown to be low impedance conductors of electricity (15). Such channels must be very thin and delicate, scarcely distinguishable from surrounding connective tissue. It is quite possible that the flow of fluid or electricity is necessary to keep them open, and if collapsed, they become virtually invisible.

The actual function of meridians remains a subject of speculation. They contain large amounts of DNA nucleotides and a number of hormones, including adrenalin. They apparently are among the earliest structures to form in the embryo, and may act as guides for the formation and later maintenance of other vessels and organs. All of these mechanisms may be involved in the transmission of microcurrents. Some routes may be more important than others, depending on the magnitude of the electrical current. In a related matter, it is known that chronically tight muscles and connective tissue suffer damage. Such dysfunction might derive not just from ischemic loss of nutrients, but an area of tightness might actually "squeeze out" essential electrolyte-containing water, changing and reducing the electrical conductivity of the tissue in that area. It has been observed by body workers that microcurrent treatment is much less effective for those who are even moderately dehydrated or lacking in electrolytes. MCT seems to require electrically conductive tissue in order to transmit current into an area. This may also be true of acupuncture.

Cellular Response to Microcurrents

We must enter the shadowy world of cell molecular biology to address the issue of how cells respond to electrical currents in a way that increases their healing activity. The effects of small currents on the cell and on the organism are equally profound, but of a very different order of magnitude. The primary organizing factor of the body now appears to be electromagnetic (12). Electricity not only influences metabolism of the individual cell, but it also tells the cell where it fits into the larger scheme of things, i.e., the organism. Electromagnetic fields form the orienting "map" by which the body forms and by which cells "know" where to go to fit in.

Cells are extremely sensitive to electrical fields, but the precise ways in which they react are not well understood. It is very tempting to speculate, as some have done, that electricity flows through the cell, charging it up in a manner similar to charging a battery. This argument, based on Cheng's proposal of augmented chemiosmosis in the mitochondria (10), claims that electricity causes the movement of hydrogen ions across the mitochondrial membrane powering formation of ATP, rather like water driving a turbogenerator. As attractive as this argument is, it contains a basic flaw. Cells are surrounded by a membrane that is mostly lipid (fat), which is an excellent insulator. It just isn't feasible that microcurrent can pass through this insulator and flow directly through cells. This theory simply is not compatible with the extraordinary complexity and sophistication of the cell.

Becker's original observations of frog red blood cells led to the conclusion that cellular changes in response to electrical currents began at the membrane and worked their way inward to the nucleus. Once affected, the nucleus directed ongoing cellular changes, even after the current was turned off (5). There seems to be a switching mechanism at the cell membrane that controls what goes on inside the cell. If an appropriate signal is received at the membrane, then the cell will change its behavior accordingly.

In the present consideration, the switch probably is triggered by calcium. Calcium ion has long been recognized as one of the important internal messengers of the cell (14). For example, the nerve impulse along an axon opens calcium gates in the axon terminal. This allows an influx of calcium ions which signals the membranes of the synaptic vesicles to merge with the presynaptic membrane, releasing neurotransmitter into the synaptic cleft. But this is only one example. The entry of calcium into the cell and the subsequent formation of a calcium-protein complex called calmodulin is necessary for the synthesis of proteins and DNA, cellular secretion, ATP recycling, and numerous other cell processes.

Obviously, the entry of calcium into the cell is implied in the control of cell growth and gene expression (i.e., differentiation and dedifferentiation). Electrical stimulation of fibroblasts increases the synthesis of protein and of DNA (3, 7). Although evidence is not yet totally conclusive, there is a strong case for the notion that microcurrent triggers productive mechanisms involving calcium gates in cell membranes (14, 16).

Calcium gates are protein inclusions in the cell membrane and have great mobility, conceptually like ice cubes in a shallow pan of water. These gates have been shown to move in an electrical field toward the negative electrode (electrophoresis) (16). Increased entry of calcium on the negatively charged side of the cell would provide a triggering directional signal to the cell. Perhaps this explains why electrode polarity often seems important in microcurrent treatment.

This phenomenon also may explain why chronically tight muscles and connective tissue suffer damage. Not only is there an ischemic loss of nutrients but, also, reduction of capillary circulation diminishes electrical conductance of involved tissue. The tightness may actually "squeeze out" the calcium-containing solution from the area of dysfunction, making this essential electrolyte less available to the cell. It has been observed by many therapists that microcurrent treatment is much less effective on patients who are even moderately dehydrated or who have low electrolyte levels. There is the additional possibility that tightness and deformity of tissue itself might reduce the conductivity of corresponding collagen and meridians.

Conclusion

Attempting to understand microcurrents gives rise to many more questions than there are answers. Precisely how these currents work in the body, what types of dysfunctions they can be applied to effect-possible contraindications, long term effects of their use are just a few of the issues that need to be addressed. Such queries lead directly to related questions about liability and licensing, which must be dealt with at a completely different level.

No doubt healing of certain types of injuries is significantly accelerated by appropriate application of microcurrent. Much of this is due to externally triggered increase of ATP (energy) formation and protein synthesis within cells. It remains for therapists and researchers to explore with sensitivity and care the best uses of this powerful tool.

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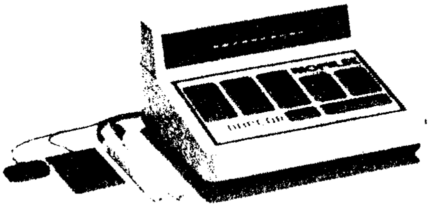

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