

Introduction

Electrotherapy or electro-medicine in recorded history dates back to 2500 BC, when the Egyptians discovered that applying a live “electric” fish to soft tissues in pain could produce a numbing effect and provide relief. In circa 1500 BC, Chinese shamans treated various illnesses by stimulating sensations such as pain, touch, and temperature using needles (acupuncture), finger pressure (acupressure), and burning herbs to impact the nerve endings in the skin. However, since knowledge of anatomy and physiology was limited in those times, such treatments were rooted in folklore and superstition. Around 47 AD Scribonius Largus, the court physician of Roman emperor Claudius, described the therapeutic use of stimulation from electric eels, to reduce pain.

In more recent times, during the industrial revolution, frictional machines producing electrostatic energy came to be used in medical treatments. Galvani, Volta, Faraday, Duchenne, Adrian and others who pioneered modern electrochemical concepts, studied the effects of electrical currents on the nervous systems of animals and humans, and provided a rudimentary scientific understanding about the effects of electrical impulses on living organisms.

The late 18th century saw Galvani rediscover the fact that animals developed electricity spontaneously, and Volta’s discovery of chemical means to produce electricity, the voltaic cell or battery. This discovery propelled the use of direct electrical current (Galvanism) in medical practice, for example in the treatment of tumors. Galvanism was also applied to needles, and the first form of electro-acupuncture, pioneered by Berlioz and Sarlandière, combined oriental healing methods with western electrotherapy in providing pain relief. Faraday's work on the production of alternating currents, and his understanding of electrolysis, provided medical practitioners with safer alternating and interrupted currents (Faradism) in electrotherapy (McDonald, A, 1993).

The twentieth century brought tools such as batteries and induction coils that facilitated the use of electrotherapy by physicians and dentists. However, by 1950, the technique still lacking adequate scientific support, was considered to be questionable by the medical community, and in some cases, even labeled as unethical. More recently, there has been a resurgence in interest in electrotherapy, particularly in the forms of electro-acupuncture, TENS (Transcutaneous Electrical Stimulation) and Dorsal Column Stimulation.

A milestone in the field of electrotherapy occurred in 1965. Public interest in electrical treatments escalated with the publication of Melzack and Wall's Gate Control Theory of pain. Until then, the medical community subscribed to postulates of the seventeenth century French philosopher René Descartes, who proposed that pain signals travel directly along a fixed pathway from the injured site in the periphery of the body to a pain center in the brain. The Cartesian theory, therefore believed the brain to be a passive recipient of pain information and pain intensity to be an index of the amount of actual tissue damage. The Gate Control Theory was based on observations of World War II veterans and their reactions to different types of injuries, and helped provide an explanation for the experience of pain on a physiological level, through the interplay of psychosomatic and biochemical factors. The original concept was complex and needed to be reworked and expanded to completely explain the role of transcutaneous stimulation on the components of the Nervous System (Melzack and Wall, 1984). Dr. Melzack's recent research at McGill University in Canada reveals the existence of two types of pain, transmitted by two separate sets of pain-signaling pathways in the Central Nervous System.

The Gate Control Theory: Closing the Gates on Pain and Accelerating the Healing Process

The Gate Control Theory breaks down the process of pain perception into the journey or flow of "messages" (impulses) along the peripheral nerves, which are outside the brain and spinal cord, and their arrival (or non-arrival) and subsequent processing, at the central command station, consisting of the spinal cord and the brain. Neurons (nerve cells) have specialized projections called dendrites and axons. Dendrites bring information to the cell body and axons take information away from the cell body. Information from one neuron flows to another neuron across a synapse. The synapse consists of a presynaptic ending that contains neurotransmitters, mitochondria, and other cell organelles, a postsynaptic ending that contains receptor sites for neurotransmitters, and a synaptic cleft or space between the presynaptic and postsynaptic endings. For communication between neurons to occur, an electrical impulse must travel down an axon to the synaptic terminal. At the synaptic terminal (the presynaptic ending), an electrical impulse will trigger the migration of vesicles containing neurotransmitters toward the presynaptic membrane. The vesicle membrane will fuse with the presynaptic membrane, releasing the neurotransmitters into the synaptic cleft.

Pain messages flow along the peripheral nerves to the spinal cord, and then on to the brain. The spinal cord represents an intermediate station with "nerve gates" that can inhibit (close) or facilitate (open) nerve impulses going from the body to the brain. On reaching the brain, the intensity of pain perception would be modulated by overlapping messages from stimuli such as touch, heat, or vibrations, as well as

the production of endogenous biochemical factors (endorphins or enkephalins) (Koman, 2005). These endogenous factors are the body's natural pain killers.

The peripheral nerves extend from the spinal cord to the skin, muscles, bones, joints and internal organs. Peripheral nerve fibers either end with receptors which respond to touch, pressure, vibration, cold and warmth, or with nociceptors which are receptors that detect actual or potential tissue damage (and are therefore concentrated in areas that are prone to injury such as the fingers and toes). On detecting a potentially harmful stimulus, nociceptors relay pain to the dorsal horn region of the spinal cord. There, they release chemicals (neurotransmitters) that activate other nerve cells in the spinal cord, which process the information and then transmit it to the thalamus region of the brain. The message is thereon simultaneously sent to three specialized regions of the brain: the physical sensation region that identifies and localizes the pain (somatosensory cortex), the emotional region that experiences distress (limbic system) and the cognitive region that assigns meaning to the pain (frontal cortex).

Thus pain messages do not travel directly to the brain, but are carried to the spinal cord by sensory nerves, and specialized nerve cells in the spinal cord act as gatekeepers, leaving the gates wide open for messages linked to bodily harm to travel immediately to the brain, while weaker, potentially non-threatening messages are filtered out, or blocked at the gates. Sudden, short-term pain, such as the pain of cutting a finger, is transmitted by a group of pathways that Dr. Melzack calls the "lateral system", because they pass through the brain stem on one side of its central core.

At least two types of small diameter nerve fibers are thought to carry the majority of pain messages to the spinal cord. The initial sensation is the activation of the fast relaying A-delta nerve fibers, followed by the activation of the slower C fibers, conferring different intensities (sharp, tingling, versus slow, throbbing or dull ache) to the pain sensation. A third type of nerve fibers, called the A-beta nerve fibers, carry pressure and tactile stimulatory messages to the spinal cord. These are very fast relaying fibers affecting the gatekeeper cells, and their counter stimulation overrides some of the pain messages conveyed by the A-delta and C fibers, thereby reducing the sensation of pain (for example when the affected area is rubbed or massaged). This is the reason why treatments such as massage, heat, cold, TNS (Transcutaneous Nerve Stimulation), or acupuncture can change a pain message.

In sensitization to pain, nerve cells in the spinal cord may release chemicals that intensify the pain, increasing the strength of the pain signal that reaches the brain. Inflammation at the site of injury may add to pain. The brain may also send messages that influence the perception of pain, by signaling the nerve cells to release natural pain killers, such as endorphins or enkephalins. This biochemical process is

influenced by several factors, including the emotional and psychological state of the individual, memories of past pain experiences, upbringing/cultural conditioning, age, gender, attitude and expectations.

Pain is generally described as chronic when it lasts six months or longer, and is often associated with diseases such as various types of Arthritis, related to painful inflammation of the joints, as well as neuropathic factors, such as damage to specific nerves, either by injury, infections or during surgery. Prolonged pain, such as chronic back pain, is transmitted by the “medial” system of nerve fibers whose neurons (nerve cells) pass through the central core of the brain stem.

Sometimes the cause of chronic pain cannot be easily identified, and it may persist long after the injury has healed or the infection has been sustained. Such chronic pain is linked to sensitization, a result of inflammation that “fires up” the nociceptors, its intensity and persistence being often fueled by psychosomatic factors.

Ion Channels and Wellness

Each living cell is surrounded by a membrane which separates the intracellular structure from its exterior. In this membrane there are channels through which the cell communicates with its surroundings. These channels consist of single molecules or complexes of molecules and have the ability to allow passage of charged atoms (ions). The regulation of ion channels influences the life of the cell and its functions under normal and pathological conditions. The German scientist Wilhelm Ostwald, who won the Nobel Prize in Chemistry in 1909, proposed in 1890 that the electrical signals measured in living tissue, could be caused by ions moving in and out through cell membranes. British scientists Alan Hodgkin and Andrew Huxley showed how ion transport through nerve cell membranes produces a signal that is conveyed from nerve cell to nerve cell like a relay race baton, and were awarded the Nobel Prize in Physiology or Medicine in 1963.

A landmark in the field of cellular ion channels was achieved in 1991. The Nobel Prize in Physiology or Medicine in that year, was awarded to German cell physiologists Erwin Neher and Bert Sakmann, who developed a technique that allows measuring the incredibly small electrical currents of picoampere (10^{-12} ampere) magnitude that passes through a single ion channel. The technique records how a single molecule can, through conformational changes, control the flow of electrical currents within a few millionths of a second. The scientists demonstrated the sequence of events during the opening or closure of an ion channel, with a diameter corresponding to that of a single sodium or chloride ion. They also showed how the channel regulates the passage of positively or negatively charged ions. These findings revolutionized

biological research and contributed to elucidating the cellular mechanisms underlying several chronic diseases, including Diabetes and Cystic Fibrosis.

An increasing amount of scientific evidence indicating a crucial role for ion channels in pain pathways now exists. In fact, these channels have become targets in the development of pain medications. Ion channels, located at the nociceptor peripheral terminal, affect neuron excitability after injury, and in turn influence the sensation of pain. Voltage gated Na^+ (sodium) and Ca^{2+} (calcium) channels, TRP (transient receptor potential channel responding to temperature, touch, pain, osmolarity, pheromones, taste and other stimuli), ASIC (acid sensing ion channel), ligand-gated ion channels, P2X (purinoreceptor channels that open within milliseconds of binding with ATP), NMDA (N-methyl D-aspartic acid, an excitotoxin), AMPA (ionotropic transmembrane receptors for glutamate that mediate fast synaptic transmission in the Central Nervous System) and kainate receptors (involved in excitatory neurotransmission by activating postsynaptic receptors, and in inhibitory neurotransmission by modulating release of the inhibitory neurotransmitter GABA (gamma-amino butyric acid) through a presynaptic mechanism), are some of the ion channels identified in the pathogenesis of pain. (Gohar, 2005, Belerdetti and Spacey, 2005).

Ion channels are also relevant in skin aging, as Ca^{2+} (calcium ion) is involved in muscle contraction. The intracellular concentration of free calcium is in the order of 10^{-8} moles/liter in the resting striated (voluntary) muscle, even though the extracellular concentration is 10,000 times higher. The Ca^{2+} ions cannot flow into the cell, due to the low permeability to calcium of the cell membrane, and to the activity of various mechanisms that bind calcium or remove it from the cell. When the transverse tubules in the cell membrane get depolarized, momentary release of intracellular calcium occurs. The entry of calcium triggers ATPase activity in the muscle protein, which helps to break down ATP, and provides energy required for contraction. Muscle relaxation takes place when a new ATP molecule binds to the contractile proteins. The intracellular calcium then returns to the intracellular compartment, and its concentration once again becomes close to a value of 10^{-8} mole/liter. Thus muscle contraction and relaxation, which influence the formation of facial lines and wrinkles, are dependent on variations in electrical potential in the muscle cells.

Pain Management with Electrotherapy

Several studies on pain management using electrical currents have been published in literature (Riley, 1975; Stanish, 1988; Ulett, 2003; for example). TENS (Transcutaneous Electrical Nerve Stimulation) devices and electro-acupuncture (EA) treatments have been studied in pain management (Chee and

Walton, 1986). TENS typically uses milliampere levels of current, and is useful in pain management. A single-blinded, randomized controlled study was conducted in 24 subjects of mean age 85 years, with knee Osteoarthritis (Ng et al, 2003). Subjects were randomly assigned to the EA, TENS, or control groups. Subjects in the EA group (n = 8) received low-frequency EA (2 Hz) on two acupuncture points (ST-35, Dubi and EX-LE-4, Neixiyan) of the painful knee for 20 minutes. Subjects in the TENS group (n = 8) received low-frequency TENS of 2 Hz and pulse width of 200 micro-seconds on the same acupuncture points for 20 minutes. In both treatment groups, electrical treatment was carried out for a total of eight sessions over 2 weeks. Eight subjects received Osteoarthritic knee care and education only, in a control group. All subjects were evaluated before the first treatment, after the last treatment, and at 2-week follow-up periods.

After eight sessions of treatment, there was significant reduction of knee pain in both EA group and TENS group, as measured by the Numeric Rating Scale (NRS) of pain ($p < 0.01$). Prolonged analgesic effect was maintained in the EA and the TENS groups at a 2-week follow-up evaluation. The Timed Up-and-Go Test (TUGT) score of the EA group was significantly lower than that of the control group ($p < 0.05$), but such change was not observed in the TENS group. The authors concluded that EA and TENS treatments were effective in reducing OA-induced knee pain. EA had the additional advantage of enhancing the TUGT results as opposed to TENS treatment or no treatment, which did not produce such corollary effect.

Other studies examined the effects of TENS and EA in cases of inflammation such as tennis elbow, Rheumatoid Arthritis, and other joint conditions, with promising results in pain and inflammation management (Chesterton, et al., 2009; Xu et al., 2009, for example).

Microcurrent Therapy Treatment for Sports Injuries: Studies and Results

Physicians who used the Electro-Myopulse in their offices have substantiated its efficacy with anecdotal reports and blinded clinical studies (Matheson, 1984). Electro-Myopulse in combination with weight training, is reported to provide a safe, effective, and non-invasive approach to rehabilitation and improvement of sports performance, in one study by Scott and Picker. Thirty subjects (males 18-35 years in age, who regularly worked out with weights) were randomly divided into two groups of 15 subjects each; one receiving the Myopulse treatment and the other being an untreated control group, receiving a matching non-stimulatory “placebo” treatment, in a blinded design. The subjects were instructed to stay with their regular workout routine for the first three treatments and pay particular attention to how the workout felt to them. At the completion of each of their workouts following each of their first three

treatments, the subjects rated how that workout felt. Starting with the fourth treatment, the subjects were told they could try to increase the amount of weight they lifted during their workout. After each of these treatments, the number of pounds lifted was noted and compared to their individual norms.

During treatment, the subjects' hands or feet were placed on grounding plates and a roller electrode, which completed the circuit, was moved very slowly over the muscle group being treated. Using the roller accessory with sufficient conductive electrolyte solution at the setting of 600 μ A and 5 Hz causes no physical sensation in the person being treated by the Myopulse. Therefore, the subjects in the treatment group experienced the same sensation as those in the control group. All subjects felt only the pressure of the smooth brass alloy roller electrode gliding firmly over various muscle groups. Three one-half hour treatments were given weekly for two weeks. The setting used for all treatments given to the subjects receiving actual stimulation was 6 cycles per second and 600 microamperes. The same procedure was followed for the control group except the instrument was not turned on. In both cases the LED's and instrument's auditory feedback were not perceptible to subjects or therapist. All of the subjects were provided the rationale behind the potential of Electro-Myopulse to increase muscle strength in athletes, and were aware that they were participating in a clinical study to validate this rationale.

All fifteen subjects in the treatment group reported significant strength increases as well as greater ease of performance during their workouts. The subjects in the control group reported minimal strength increases and/or performance enhancement. Two of the subjects in the control group dropped out, complaining "the machine didn't work", before completing the six treatments.

Strength level increased by approximately 15% in the subjects receiving real stimulation, as against approximately a 2% increase in the control group. These results positively support the claim that the Myopulse can improve strength in athletes.

In a field study at the Los Angeles International Marathon in February 1984, a group of Acuscope therapists were assigned to work with elite marathoners (Matteson, Matteson & Huey, 1984). The basic procedure was to provide massage and Acuscope treatments for those runners requesting assistance. Thirty athletes were treated for injuries such as sprained ankle and Achilles tendon (8), hamstring spasms (8), abductors (4), calf strains (3), quadriceps tightness and knee strains (4), and hip and gluteus pain (2). 94% of the treated individuals reported reduction in "pain", increase in range of motion, reduction of tightness in areas affected, and an overall general sense of improved well-being. Treatment times ranged from 15 minutes with less severe cases (e.g., knots, muscle spasms) to 30-40 minutes in cases of severe

muscle spasms and metabolic imbalance. In the latter case, one marathoner was brought in on a stretcher with severe stomach cramping and rigid abductors. Pain was so intense that only minimal probe pressure could be applied. However, in approximately 15 minutes, the area had stabilized to allow for firmer body/probe contact. After 40 minutes, the participant was able to stand and walk without assistance. Several reports accentuate the beneficial role of microcurrent therapy in relieving pain and loss of mobility occurring with sports injuries, since the invention of the Electro-Acuscope in 1978. One remarkable evidence of its benefits was in the case of Freddie Solomon, who played 11 seasons of football for the Miami Dolphins and San Francisco 49ers between 1975 and 1985. The 49ers won two Super Bowls with Solomon as a member. A 5'11", 184-lb. wide receiver from the University of Tampa, Solomon injured his knee during practice, just before Super Bowl XVI in 1982. The injury happened during a supposedly "non-contact workout" when Solomon was running a pass play against the 49ers' defense, and collided with the quarterback. Solomon suffered a twisted knee injury on falling. The injury became more painful during the day, and it was not likely that he would play in the Super Bowl on Sunday. However, Solomon was given electronic treatments by Herb Berger, a therapist who specialized in electrotherapy. Using the Electro-Acuscope, Berger began stimulating Solomon's left leg in the injured area. Solomon experienced pain relief, was able to play as scheduled, and was instrumental in the 49ers' victory. (Oakland Tribune, Eastbay Today/Sports, January 1982, Peter Clark). Sports teams including the 49ers, Oakland A's, and the San Francisco Giants, used the Electro-Acuscope in the 1980's to treat athletic injuries.

Several other professional athletes from various sports concentrations were introduced to the Electro-Acuscope and Myopulse when they sustained sports injuries resulting in chronic pain. Veteran golfer Jack Nicklaus, Olympic champions Joan Benoit and Mary Decker, football stars Terry Bradshaw and Joe Montana, and hockey great Wayne Gretzky are among the many athletes who have benefited from using the Acuscope and Myopulse.

Terry ("Man of Steel") Bradshaw suffered neck and wrist injuries early in his career and an elbow/triceps triple injury in 1983 that necessitated surgery. He experienced over 90% post-operative pain relief and at a later time complete pain relief in seven treatments with the Electro-Acuscope, that enabled him to return to practice with the Steelers and regain his starting position within two weeks. Bradshaw himself stated that a 15-minute treatment in the elbow area was enough to eliminate the pain. Joe Ferguson received over 90% pain relief from a post-traumatic injury sustained after being tackled in a N.Y. Jets game in November, 1983. Another example, Mike Barber of the L.A. Rams, experienced 95% relief of pain from a rotator cuff injury with only two treatments on the Acuscope (Matheson, 1984). In another

remarkable case, just seventeen days after arthroscopic surgery on her right knee, and then a hamstring pull on her left leg that occurred while training after the surgery, Joan Benoit won the first women's Olympic marathon trial in 2:31:04, thanks to the Electro-Acuscope. It is important in this context to note that Acuscope can relieve the pain of an injury and effect a speedy recovery, but if the cause of the injury is not found and corrected, the pain may be back again (Miracle Worker, Eric Olsen).

Lower back pain generated through “overuse” of back muscles by golfers, was successfully treated with the Electro-Acuscope and Myopulse, throughout the 1980's. A fitness center housed in a trailer and equipped with the instruments, followed professional golfers on their tours to provide pain relief to sufferers. The center came about through the combined efforts of the PGA Tour and Diversified Products, the world's largest manufacturer of exercise equipment. Research into the biomechanics of the golf swing was conducted by nationally known orthopedic consultant Frank W. Jobe, MD, Founder and Director of the National Athletic Institute at Centinela Hospital Medical Center, in California. Dr. Jobe served as an orthopedic consultant to the President's Council on Physical Fitness and Sports, the Los Angeles Lakers basketball team, the Los Angeles Rams football team, the Los Angeles Kings hockey team, the Los Angeles Dodgers and California Angels baseball teams, and the PGA Tour. The Acuscope delivered about 500-millionths of an ampere current to affected nerve tissue, generating relief at the cellular level and the Myopulse worked similarly upon connective tissue to produce a state of homeostasis within the involved tissue, by subtle electronic interaction (American Medical News, 1985).

College athletes, such as baseball player Carmel senior Bob Langer, injured in a freak baseball game accident, have also benefited from the Electro-Acuscope and Myopulse. Two players ran into the boards and the Plexiglas popped out as Langer sat nearby. The glass tilted over on top of his leg, resulting in a broken right fibula that necessitated a cast for six-eight weeks, with several more weeks of rehabilitation. The diagnosis was that he would never play baseball again. However, a physical therapist, Paul Conway, suggested Electro-Acuscope and Myopulse therapy, and effected the treatment through a hole cut in Langer's cast. Before long, he was no longer in pain, and was able to play baseball again, going on to receive a scholarship based on his performance (Daily Herald, 6/3/88, Langer's Impact Shows).

A combination of techniques including microcurrent therapy was used in a case of Posterior Interosseous Neuropathy (PIN) occurring in an elite baseball pitcher experiencing a deep ache in the radial aspect of the forearm and altered sensation in the dorsum of the hand on the throwing arm during his pitching motion (Robb et al., 2009). The initial clinical goal was to control for the inflammation to of the nerve and muscle with active rest, microcurrent therapy, low-level laser therapy, and cessation of throwing.

Minimization of mechanosensitivity at the common extensor region of the right elbow and PIN, was achieved by employing the use of myofascial release and augmented soft tissue mobilization techniques. Neurodynamic mobilization technique was also administered to improve neural function. Implementation of a sport-specific protocol for the purposes of maintaining throwing mechanics and overall conditioning was utilized. Successful resolution of symptomatology and return to pre-injury status was achieved in 5 weeks.

Microcurrent Therapy in Post-Polio Syndrome and in the Management of Radiation Treatment Sequelae

Post-Polio Syndrome affects over 75,000 people in the United States alone. One study evaluated the effectiveness of electro-stimulation of auricular acupuncture points in the treatment of confirmed Post-Polio Syndrome patients. Short and long long-term responses in 12 study subjects were measured. Good or excellent results were obtained in all patients, with 66.7% reported reporting a return to their pre-existing levels of health. This clinical experience shows that this modality can be effective as a permanent, relatively simple and inexpensive form of therapy for this condition (H'Doubler, 1994).

Radiotherapy induces a range of late onset symptoms, including tongue immobility, impaired speech, stiffness, facial asymmetry, soft tissue edema, trismus, dry mouth, difficulty swallowing, cervical and facial spasms, fibrosis, inability to purse lips, difficulty breathing, tenderness, pain and numbness. Between January 1998 and June 1999, 26 patients who were experiencing late effects of radiotherapy were treated twice daily with impedance-controlled microcurrent therapy for one week. Objective range-of-motion measurements were made for cervical rotation, extension/flexion, and lateral flexion, before therapy, at the end of each treatment day, and monthly for three months. In addition, each patient's subjective complaints were tabulated before treatment and reevaluated at the last follow-up visit. No additional physical therapy or electrical stimulation was permitted during the follow-up period.

At the end of the course of microcurrent therapy, 92% of the 26 patients exhibited improved cervical rotation, 85% had improved cervical extension/flexion, and 81% had improved cervical lateral flexion. Twenty-two patients returned for 3-month follow-up visit. Of these, 91% had maintained a cervical rotation range-of-motion greater than their pre-therapy measurements. In addition, 82% maintained improved cervical extension/flexion and 77% maintained improved lateral flexion. When the range-of-motion measurements were stratified by pre-treatment severity (severe, moderate, mild, asymptomatic), the degree of improvement directly correlated with the severity. Thus, patients who had more severe initial symptoms experienced a higher percentage of improvement than did those with milder symptoms.

Some patients also reported symptom improvements in tongue mobility, facial asymmetry, xerostomia (dry mouth), cervical/ facial muscle spasms, trismus, and soft tissue tenderness. No adverse effects were observed (Lennox, et al., 2002).

Microcurrent Therapy to Support Lymphatic Detoxification

Obstruction and congestion of the Lymphatic System is believed to facilitate a breeding ground for pathogenic organisms that foster disease. Since the Lymphatic System is involved in draining away toxins, it is important to restore and maintain proper lymphatic function. Lymphatic detoxification treatments have serious limitations and usually do not have long long-lasting effects. Electro-Acuscope therapy provides a viable alternative. A homeostasis is created in the Autonomic Nervous System, as explained earlier in the text, which allows lymphatic congestion and blockage to be relieved. Therefore, trapped blood protein clusters are broken up and unobstructed lymphatic flow is re-established. Clearing the Lymph System, a component of the Immune System, significantly enhances the efficiency of the body to deal with pathological conditions (Gregory, 1995).

Microcurrents in Diagnosis and Treatment: L- Fields

Dr. Harold Saxon Burr, who was a Professor Emeritus at Yale Medical School, discovered in the 1930's, that all living things are molded and controlled by electro-dynamic fields, which could can be measured and mapped with standard voltmeters. These "fields of life", or L-fields, are the basic blueprints of all life on this planet. Dr. Burr believed that, since measurements of L-field voltages can reveal physical and mental conditions, doctors should be able to use them to diagnose illness before symptoms develop, and so would have a better chance of successful treatment. He examined the electrical properties of cancer-susceptible mice to determine if the voltage measurements would change during the initiation and growth of cancer tissue. In his own words, "The results of the experiment were surprisingly consistent. Twenty-four to twenty-eight hours after the implantation, changes were observed in the voltage gradients. This differential increased steadily and quite smoothly to reach a maximum of approximately five millivolts on or about the eleventh day. In the slow-growing tumors, potential differences began to emerge on the third or fourth day, but reached their maximum of approximately three millivolts on the tenth or eleventh day."

Dr. Burr also conducted numerous experiments with Dr. Leonard J. Ravitz Jr., a colleague in the Department of Psychiatry at Yale. Dr. Ravitz found that they could establish baseline voltage gradient measurements for individuals who had normal mental functioning. "It became obvious to Dr. Ravitz's examination that by using electro-metric techniques on patients in psychiatric hospitals, patients – as a result of therapy or changing circumstances – could safely be discharged from the hospital when the voltage gradient indicated a reasonable return to normal."

One of Dr. Burr's most exciting discoveries dealt with the recording of voltage changes during female menstrual cycles. For the first time, it was revealed that the moment of ovulation can accurately be determined by measurement of electric fields. This discovery had practical implications in planned pregnancy, as the onset of ovulation could be predicted through measurements of voltage (Burr and Northrop, 1939; Burr, 1972).

Microcurrents, Electro-sleep and Relaxation

Electro-Acuscope can be used to reduce stress-related problems in combination with selected electrodes placed on the ear lobes or the frontal bone of the head, and set to appropriate frequencies. This procedure, also known as "Electro-Sleep" (a misnomer, as this is relaxation, not sleep) or Cranial Electric Stimulation (CES), has been applied successfully in medical offices, ranging from dentists to psychiatrists. The mind regulates its activities by means of electric waves which are registered in the brain, and emit tiny electrochemical impulses of varied frequencies, which can be registered by an electroencephalogram. These brainwaves include Beta waves emitted in a state of conscious alertness, or in the agitated, tense, fearful state, with frequencies ranging from 14-30 Hz; Alpha waves associated with a state of conscious physical and mental relaxation, at a frequency of 7.5-14 Hz; Theta waves more at a frequency of 3.5-7.5 Hz, in a state of somnolence with reduced consciousness; and Delta waves when there is unconsciousness, deep sleep or catalepsy, emitting between 0.1 and 3.5 Hz.

A state wherein the brain rhythm is in the alpha range, is conducive to learning, memory, mental clarity and analysis. Meditation, relaxation exercises and activities that enable a sense of calm also facilitate Alpha waves. The Alpha (7.5-14 Hz) spectrum is usually produced as rhythms of steady frequency and amplitude. It is associated primarily with pleasant inward awareness, a non-drowsy but relaxed state, and tranquil state of mind. Outside stimulation usually interrupts this Alpha rhythm. The Theta (3.5-7.5 Hz) level is associated with an access to unconscious material, drowsiness, fantasy, imagery, dreaming recall, problem-solving, inspiration and creativity. Advanced students of Yoga, Zen and other forms of

meditation or inner-awareness appropriately display an ability to produce enhanced (high amplitude, low frequency) Alpha and Theta state activity, a condition that is stimulated by electrotherapy with Acuscope and Myopulse, as well.

This non-invasive procedure potentially reduces mental fatigue, enhances autonomic stability, improves concentration and, as a general procedure, prepares the patient for treatments, including surgery. Benefits in hyperactive children, depressed individuals, insomniacs, cases of anxiety, headache, migraines, visual disturbances and head trauma, are also known. Other research investigations demonstrate the potential applicability of electro-sleep in other lifestyle stress-related areas such as obesity, addiction, compulsion, alcohol and drug detoxification, and in conditioning to life style improvements. Opportunities for applications in treating jet lag also exist.

In studies in Russia and by university researchers in the US, patients with chronic anxiety, depression, and nocturnal insomnia, who had failed to respond to conventional methods of treatment were selected to receive electro-sleep therapy. The use of electro-sleep with these same patients, however, showed significant improvements in their conditions.

Innovative muscle stimulation techniques have also become alternatives for therapy of obstructive sleep apnea syndrome breathing disorders (Ludwig, 2008).

Microcurrent Therapy in Skin Care

In the Peripheral Nervous System, the junction between a nerve and a muscle constitutes the neuromuscular plaque, upstream of which is the efferent nerve pathway known as the motor neuron. The cell membranes of each nerve fiber also comprise numerous ion channels, and in particular, calcium ion channels. Thus the role of calcium ions in regulating muscle contraction and relaxation is an important one. In the context of anti-aging therapies, reducing the contraction or hyper-contraction of certain facial muscles would in turn reduce the appearance of wrinkles. As explained earlier, such an effect would stem from a variation in the flow of calcium through transmembrane calcium channels.

A neurotoxin such as the botulinum toxin, can act on states of muscular spasticity (Blitzer et al., 1993), and on wrinkles between the eyebrows (Carruthers et al., 1992). It is therefore possible to favorably influence the neuromuscular component of wrinkles, to achieve “anti-aging” benefits, through effects on the electrochemical potential gradient between the cell and its environment, which in turn influences Ca^{2+} ion transport. Permeability of the cell membrane to calcium ions corresponds to the opening of

membrane calcium channels, wherein these channels respond to variations in membrane potential (VOC) or activation of membrane receptors (ROC). To date, six VOC types of calcium channels (L, N, T, P, Q and R) have been identified. Voltage dependent calcium channels link membrane potential changes of excitable cells to important cellular processes, including regulated secretion of neurotransmitters and hormones, muscle contraction and gene transcription.

Another significant concept in this context pertains to the role of bioelectrical forces in maintaining health and wellness. At the cellular level, pathology or disease begins with disruption of the bioelectrical potential gradient across the cell membrane, which in turn, disrupts normal metabolic processes and energy balance. For example, a disruption in sodium transport reduces the efficiency of energy metabolism and the production of ATP. Metabolic dysfunction or build-up of metabolic wastes and toxins along with an increase in electrical resistance, are natural consequences, which exacerbate signs of aging.

Inflammation is now considered to be the root cause of chronic diseases, ranging from cardiovascular conditions, to Arthritis, and various forms of cancer. Inflamed or injured tissue has been shown to have a higher electrical resistance than surrounding healthy tissue. In skin aging, inflammation at various sites produces a “micro-scar” which later matures into a wrinkle or age spot. Inflammation may be induced by injury, exposure to pollutants or adverse environmental factors, ultraviolet radiation, microbial overgrowth, and chemicals.

Inflammation is a protective attempt by the body to remove noxious stimuli, as well as to initiate the healing process for the tissue. There is increasing evidence that conditions characterized by an intense local or systemic inflammatory response are associated with abnormal ion transport (Eisenhut, et al. 2006). Ion transport is essential in the maintenance of electric potential across the cell membrane, fluid transport, and optimal cellular volume.

Components of ion transport systems, which have been shown to undergo a change in function during an inflammatory response include the sodium potassium ATPase (that breaks down ATP to provide energy), the epithelial sodium channel, the Cystic Fibrosis Transmembrane Conductance Regulator, calcium-activated chloride channels and the sodium potassium chloride co-transporter. Inflammatory mediators, which influence ion transport, are tumor necrosis factor (TNF-alpha), gamma interferon, interleukins, transforming growth factor, leukotrienes and bradykinin. They trigger the release of specific messengers

like prostaglandins, nitric oxide and histamine which alter ion transport system function through specific receptors, intracellular second messengers and protein kinases (PKC).

Consider the molecular aspects of skin aging, which is influenced by the expression of tissue degrading enzymes such as collagenase and elastase (matrix metalloproteinases, MMP). Transient receptor potential vanilloid type 1 (TRPV1) is a molecular sensor for detecting adverse stimuli, such as capsaicin, heat, and acid. TRPV1 has been localized in keratinocytes, and is suggested to be a mediator of heat-induced matrix metalloproteinase-1 (MMP-1). UV-induced MMP-1 expression might be mediated, in part, by PKC-dependent activation of TRPV1 and subsequent Ca²⁺-influx in human keratinocytes. (Lee et al, 2009).

Skin hydration is an important criterion in aging. Aquaporins (AQPs) are proteins that facilitate the transport of water across cell membranes. AQP3 expression is related to the expressions of other epidermal proteins involved in water maintenance (CD44, claudin-1, and filaggrin). The expressions of AQP3 water channels are strongly affected by age, and chronic sun exposure. A defective osmotic equilibrium could occur in the epidermis, which would account for the skin dryness observed in older people and skin areas most exposed to sunlight (Dumas et al, 2007).

Other skin conditions such as cellulite, are also affected by the sodium (Na⁺) potassium (K⁺) pump and Ca²⁺ balance. It is therefore potentially possible to reduce inflammation and pain, accelerate healing, and regenerate tissue, and reduce the signs of skin aging, using microcurrents that positively influence ion transport. It is, however, important to deliver the exact requirement of stimulation to achieve the desired effects. A microcurrent therapy system needs to have biofeedback capabilities, to enable automatic adjustment of current delivery, based on the level of electrical resistance detected in the tissue in need of healing.

Research: The Role of Microcurrent Therapies in Tissue Healing & Regeneration

Microcurrent therapy is essentially a refinement of traditional milliamp electro-stimulation techniques that follow the current trend of less invasive treatments (Davis, 1992). The healing process encompasses a number of electrochemical reactions involving increased local circulation and enhanced movement of nutrients and metabolic waste in and out of the cells. Electrical fields are therefore an essential component in providing enough energy to fuel this regenerative activity. When the cells are unable to sustain sufficient levels of micro-electricity, the cell remains in a diseased state, with insufficient energy

for metabolic functions. Regenerative capability is limited in higher vertebrates but present in organ systems such as skin, liver, bone, and to some extent, the nervous system.

Electric and electromagnetic fields (EMFs) have been used to heal fracture non-unions. This technology emerged as a consequence of basic studies (Yasuda, 1953; Fukada and Yasuda, 1957), demonstrating the piezoelectric properties (the ability to generate an electric field or electric potential in response to mechanical stress) of dry bone.

The principle for using electrical stimulation for bone healing originated from the work of Bassett and Becker, who described asymmetric voltage waveforms from mechanically deformed live bone, in 1962. These changes were presumed to occur in bone during normal physical activity as a result of mechanical forces, and it was postulated that these forces were linked to modifications in bone structure. Endogenous currents present in normal tissue and those that occur after injury were proposed to modify bone structure (Bassett, 1977; Becker, 1985, Hinsenkamp, et al., 1978). These investigators proposed that tissue integrity and function could be restored by applying electrical and/or mechanical energy to the area of injury. They successfully applied electrical currents to non-healing fractures (using surgically implanted electrodes or pulsed currents using surface electrodes) to aid endogenous currents in the healing process. One of the first studies that reported the positive effects of microcurrent stimulation in wound healing was published in 1969 (Walcott, et al). Microcurrent stimulation in the range of 200-800 microamps was applied to a wide variety of wounds using alternating current polarities. A control group was treated with ordinary wound care methods. The microcurrent treated group showed 200-350% faster healing rates than conventionally treated controls. The scar tissue in this group had greater tensile strength and antimicrobial effects were also observed.

In a later study (Gault and Gatens, 1976), a similar procedure was used on patients with varied conditions including quadriplegia, CVA brain tumor, peripheral vascular disease, burns, diabetes, tuberculosis, fracture and amputation. Microcurrent therapy resulted in healing times that were 50% lower than those observed in conventionally treated controls.

A landmark study by Cheng, et al (1982), sought to establish the mechanism of action of microcurrents in wound healing. This *in-vitro* study used varying levels of electrical stimulation on slices of rat skin. Free amino acid levels and ATP levels were measured in treated and untreated control slices. Up to 75% increased free amino acid levels and up to 400% higher available ATP levels in specimens treated with currents below one milliamp, were observed in the treated group as compared to the control group. The

most significant finding in this study was that currents above one milliamp produce decreased levels of free amino acids and ATP as compared to untreated controls. The study concluded that microcurrent therapy is therefore potentially useful in facilitating tissue healing and regeneration.

Other studies have demonstrated beneficial effects of microcurrents in accelerating healing of bones, tendons, and in collagen remodeling. To study the effects of microcurrents on superficial wounds, keratome-induced wounds (0.3 mm deep) on the skin of young domestic pigs were treated with either an energized (50–300 microampere) electrode (DC), an unenergized electrode (placebo), or left untreated (Alvarez, et al., 1983). Wounds were excised on days 1–7 after wounding, and the epidermis was separated from the dermis. The epidermal sheet was evaluated for reepithelialization, and the dermis was assayed for collagen biosynthetic capacity. Dermal collagen production among treatments did not differ markedly on days 1–4 after wounding. However, a highly significant increase ($p < 0.001$) in the collagen synthetic capacity was observed on days 5, 6, and 7 in wounds treated with DC. There was no significant difference in collagen synthesis among treatments when collagen production was corrected for DNA content. The rate of wound epithelialization was also significantly accelerated ($p < 0.05$) in DC-treated wounds. These results suggest that the proliferative and/or migratory capacity of epithelial and connective tissue cells involved in repair and regeneration can be affected by an electrical field.

Carley, et al., (1985), specially constructed a small and portable LIDC (low intensity direct current) stimulator delivering 200-800 microamps and used it to study the effects of microcurrents on wound healing rates in of inpatients at a clinic. Thirty patients with indolent ulcers located either below the knee or in the sacral area were randomly assigned to the LIDC protocol or to more conventional wound therapy. The patients in each treatment group were matched by age, diagnosis, wound size, and wound etiology. Comparison revealed 1.5 to 2.5 times faster healing in those receiving LIDC, which is statistically significant. The wounds treated with LIDC required less debridement and the healed scars were more resilient. Additionally, no wound infections occurred and patients reported less discomfort at the wound site. The authors concluded that low intensity direct current appears to be a convenient, reproducible, and effective method for improved healing of chronic open wounds and warrants more widespread use in the clinical setting.

Nessler et al (1987) examined the effect of direct-current electricity on healing *in-vitro*. Deep flexor tendons of rabbits were excised, transected, repaired, and grown in an acellular culture medium for seven, 14, 21, or 42 days. Tendons through which a continuous 7-microamp current was passed at the repair site were compared with non-stimulated controls. The incorporation of labeled (^{14}C) proline and its

conversion to (14C) hydroxyproline was measured at seven days. The mean (14C) proline and (14C) hydroxyproline activities were 91% and 255% greater, respectively, in the stimulated group, demonstrating enhanced potential for collagen synthesis. The activity was also higher in the stimulated group, within 42 days. Histologic sections showed that intrinsic tenoblastic repair may be enhanced with electrical stimulation *in-vitro*.

A comprehensive review detailing the beneficial effects of electrotherapy in healing skin ulcers was published in 1989. Biedebach summarized evidence from 8 studies involving 215 clinical patients with ischemic skin ulcers and 7 animal tissue or tissue culture studies. These studies provide direct evidence that electrical stimulation of fibroblast cells accelerates the intracellular biosynthesis necessary to form new granulation tissue in a healing wound, and that both a direct local tissue effect and a circulatory improvement occur. Dr. Biedebach presented a model in which transmembrane currents open voltage-controlled calcium channels in fibroblast cells, causing ATP resynthesis, activation of protein kinase mechanisms to synthesize new cellular protein, and the DNA replication necessary for mitotic cell division. He postulated that stimulation efficacy appears to be determined by a number of basic electrical parameters, and judicious waveform control is desirable, to achieve positive benefits. An excerpt from Dr. Biedebach's review is included here for ready reference (Biedebach, 1989; Assimacopoulos, 1968; Wolcott et al., 1969; Gault et al., 1976; Carley et al., 1985; Omura 1971, 1973, 1975, 1981, 1983, 1985; Barron et al., 1985; Alon et al., 1986; Kloth et al., 1988).):

Beneficial Effects of Electrotherapy in Healing Skin Ulcers

Number of Patients	Type & Number of Ulcers	Type of Treatment	Hours of Total Treatment Time/Week	Average # Weeks for Healing	Healing Rate per Week
3	6 (venous stasis)	Low intensity D.C. (75-100 microamp)	168	4.4	--
67	8: control 75: treatment (ischemic ulcers)	Low intensity D.C. (600 microamp)	42	9.6	13.4%/week healing rate vs. 5%/week for controls
76	6: control 100: treatment (ischemic ulcers)	Low intensity D.C. (200-1000 microamp)	42	4.7	30%/week healing rate vs. 14.7%/week for controls
30	15: control 15: treatment (indolent ulcers)	Low intensity D.C. (300-700 microamp)	20	5	17.9%/week healing rate vs. 9% week for controls
2	Multiple small ulcers	Biphasic pulses 1.5-2 pulses/sec 3-6.5 volts, 200 microsecond Duration	0.5	2	--
6	6 decubitus ulcers (treatment up to 1 year)	Biphasic pulses 600 microamp at 0.5Hz, electronic waveform control	3	4	--
15	15 diabetic (persisted for avg. 8.6 months)	High voltage short duration pulses (80Hz)	3	11.3	--
15	7: control 9: treatment Stage IV decubitus ulcers	High voltage short duration (50 microsec. pulses)	3.7	7.3	44.8%/week

Sisken et al. (1999) presented a case for the use of electric and electromagnetic fields in accelerating nerve regeneration. In more recent research, (Lee et al, 2007), investigators studied the efficacy of ultra-low microcurrent delivered by an Electro Pressure Regeneration Therapy (EPRT) device for the management of chronic wounds. 23 patients with chronic skin ulcers and two patients with abdominal dehiscence that was present for an average of 16.5 months, who were not responsive to conventional treatment in a hospital setting, were treated with the EPRT device. Wounds were treated with direct current (maximum of 3 mA) of 1 polarity for 11.5 minutes and then with a current of the opposite polarity for another 11.5 minutes. Treatment was applied through ultra-low microcurrents (in the microamp to nanoamp range) conducted through special wraps applied above and below the wound. The results revealed that 34.8% of cases achieved complete wound healing after an average of 45.6 hours of treatment, and 39.1% achieved greater than or equal to 50% healing after an average of 39.7 hours of treatment. Several patients achieved significant results after 1 to 2 treatments. The authors concluded that the EPRT device not only accelerated healing but also appeared to negate the effect of a person's age on wound healing.

The mechanism of “healing” postulated is that electrical current, when flowing outward through a portion of the membrane of a fibroblast, causes sufficient membrane depolarization to allow calcium inflow through the cell membrane. The resulting elevation in intracellular calcium level would in turn, increase ATP production within the mitochondria, and activate protein kinase mechanisms necessary to stimulate transcription and translation processes to produce new cellular protein. These mechanisms play an essential role in initiating mitotic cell division and migration (Biedebach, 1989). It is likely that such a ligand-independent mechanism functions in normal wound healing, in conjunction with ligand-dependent mechanisms. It is also likely that fibroblast cells respond to the naturally occurring “wound current”, originally discovered by Dubois-Reymond in the last century, and since verified by many other investigators (Dubois-Reymond, 1860; Barker et al., 1982). Barker et al. investigated the presence of the “mammalian battery” using a guinea pig skin model. They found that voltages across various glabrous (and gland-free) regions of guinea pig skin range from 30-100 mV, inside positive; across hairy ones, 0-10 mV. When an incision is made through the glabrous epidermis of the skin, a microampere was measured to flow through each millimeter of the cut's edge. These wound currents generated lateral, intraepidermal voltage gradients or fields of about 100-200 mV/mm near the cut; that declined with distance from the cut with a space constant of 0.3-0.4 mm. The authors concluded from these data that the epidermis near a cut drives fields up to 300 microamp/cm². They also confirmed that hairy areas in the epidermis of mammals (including humans) tend to maintain lower transcutaneous voltages.

Mechanism of Pain Relief and Tissue Healing In a Nutshell

Kaada (1987) determined that transcutaneous electrical stimulation of human skin tissue induces the release of vasodilating substances. Transcutaneous nerve stimulation and the injection of .2 ml of 10^{-10} M calcitonin gene-related peptide (CGRP) both cause an increase of blood flow in rat musculocutaneous flaps that follow virtually identical time courses (Kjartansson et al., 1988) This time course is very different from the time course in the change in blood flow that occurs in this preparation when sympathetic vasoconstrictor nerves are blocked. In 1989, Maggi et al. found that CGRP is released from the endings of sensory nerve fibers in the isolated guinea pig atrium in response to electrical field stimulation in the bath (3 Hz., 1 msec, and approximately 0.35 volts/mm field intensity) and also by the depolarizing effect of using high potassium medium. The release of another vasodilatory neuropeptide, substance-P, a tachykinin, was also identified. Substance-P is required, however, in a concentration that is approximately 1000% that of CGRP to achieve the same vasodilatory effect (Lembeck and Holzer, 1979). The release of both substances was found to be blocked by omega conotoxin, from a marine snail, a known blocking agent for both the L and N types of voltage-sensitive calcium channel (Fox et al., 1987). The release of the substance-P from cultured dorsal root ganglion nerve cells in both the rat and the chick was also found to be sensitive to dihydropyridine (DHP). This demonstrates that the voltage-sensitive calcium channel on these sensory nerve cell bodies is primarily of the L-type (Holz, IV et al., 1988 and Perney et al., 1986).

Analgesic effects are induced when depolarization of nerve endings in local tissue by electrical current pulses opens calcium channels and causes a calcium influx sufficient to release significant quantities of the neuropeptides including CGRP and Substance-P. Substance-P, secreted by smaller diameter primary sensory nerve endings (Pernow, 1983), has been found to stimulate DNA synthesis (required for cell division) in connective tissue fibroblasts and also in epithelial cells (Nilsson et al., 1986 and Sporn et al., 1988). CGRP has been found to increase (in a dose dependent fashion) the synthesis and release of glycoaminoglycans (GAG), by fat-storing cells (Casini et al., 1991). CGRP binds to specific receptor molecules in the plasma membranes of those cells (Maggi et al., 1991) GAG has side chains that bind to molecules in both the plasma membranes of tissue cells and the extracellular matrix, acting as a “glue” that holds and establishes the integrity of newly-formed cells within the structure of freshly healed tissue.

The dura mater membrane surrounding the brain has a high density of nerve fibers containing CGRP and substance-P (Keller and Marfurt, 1991). Electrical stimulation of these fibers has been found to release these vasoactive peptides (Zagami et al., 1990). Increased blood flow results in removal of pro-inflammatory and pain mediators, such as prostaglandins from arachidonic acid that are responsible for

initiating the pain and inflammatory responses. An electric field strength of 1000 millivolts per millimeter (sufficient to depolarize the cell membrane voltage of a 20 micron cell by 15 millivolts) almost tripled the rate at which calcium ions enter human fibroblast cells (which have primarily L-type voltage sensitive calcium channels), and trigger relief and healing processes.

Microcurrents in Reversing Signs of Tissue Aging: An Integrated Approach

The applications of microcurrent therapy in potentially reversing the signs of tissue aging are being researched and used in dermatological settings. In an effort to develop integrated treatments in dermatological practice, microcurrent therapy in combination with other treatment modalities is being explored.

One group of researchers investigated the effects of topical application of an Aloe Vera gel with or without microcurrent application on the healing of skin wounds surgically induced in Wistar rats. The animals were randomly divided into four groups: a control group, a group topically treated with Aloe Vera, a group treated with microcurrent, and a group receiving topical application of Aloe Vera combined with microcurrent application. The results indicated differences in wound healing between the various treatments as compared to the control group. Tissue hyperplasia was lower in the control group, as compared to the other treated groups. Accelerated wound healing was observed in the group treated with Aloe Vera as compared to control. Animals submitted to microcurrent application only, and the group treated with microcurrent plus Aloe Vera, presented an earlier onset of the proliferative phase compared to the control group and animals treated with Aloe Vera gel alone. Morphometric data confirmed the structural findings. The authors concluded that simultaneous application of Aloe Vera gel and microcurrent is an excellent choice for the treatment of open wounds, thus indicating a synergistic action of these two applications (Mendonca, et al, 2009).

Electro-Acuscope and Electro-Myopulse: A Revolution in Microcurrent Therapy

The intelligent microcurrent technology of Electro-Acuscope and Myopulse has been in use internationally for over 29 years to address a range of conditions having their roots in the inflammatory process, including migraine/tension headaches; whiplash injury; neck, shoulder, and back pain; TMJ (tempomandibular joint) disorder; muscle tightness and spasm; bursitis; tendonitis; arthritis; post-operative healing; surgical scars; sprains; strains; neuralgia; herpes zoster (shingles); bruising; and others. Applications in the management of sports injuries, the treatment of dermatological conditions, in supporting wound healing,

and in veterinary practice (equine) are well-documented, both by anecdotal evidence and controlled clinical studies.

In these instruments, microprocessors that are modulated by feedback information from the affected tissue trigger a microcurrent with "waveform control" that helps support and initiates the body's own natural healing abilities.

This sophisticated system includes two separate pieces of equipment, the Electro-Acuscope and the Electro-Myopulse, which together, comprehensively address the neuromuscular roots of pain and tissue degeneration. This unique system generates very low voltage and amperage electrical current in tune with biofeedback signals from the tissue in need of support. Unlike TENS units, which supply current in the milliamperage range, the electrical current supplied by the Electro-Acuscope and Myopulse is in the microampere range. Microcurrents have been shown to be more efficacious in potentially reducing pain and regenerating tissues than milliamperage level currents (Cheng, et al, 1982).

In essence, these instruments establish two-way communication between their own internal computer circuits and the bioelectrical circuits in the area of living tissue being subjected to microcurrent. The waveforms produced by the instruments simulate the body's own electrical signals, to overcome the increased resistance present in inflamed tissue, thereby supporting the restoration of normal waveform conductance. The tissue thus receives a subtle impetus to heal itself naturally.

Electro-Acuscope: This exceptional instrument reads neurological impedance along the linear pathways of current flow (nerves, meridians) and can discriminate area points of high and low resistance (acupressure and trigger points). In addition to beneficial effects in pain and inflammation management, the microcurrent from the Acuscope also influences the Autonomic Nervous System with potential benefits in the treatment of stress symptoms and sleep disorders.



Acuscope technology comprises a micro-controller (processing unit), assisted by P.A.L. technology (programmable array logic gates) devices, to help autoscan bioelectric potentials in the tissue, store that information, and then supply optimal microcurrent dosage to effect the required polarization in the tissue. Electro-Acuscope causes directed polarization, and the result of the activity in the membranes is to restore normal activity in the tissue.

Acuscope treatments are usually painless. A small percentage of patients feel a tiny pulse, or just a slight stinging like tiny needles lightly pricking the skin, which can be eliminated by adjusting the settings. During treatment, most patients feel nothing, except their experience of relief, and report only the sensations of general relaxation, warmth, or a comfortable tingling in the area being treated.

Treatment probes or electrodes are usually moistened with a specially-formulated transmission gel or electrolyte and electrodes are then applied to the surface of the skin. Some patients with swelling and extreme sensitivity to touch may experience some discomfort from the pressure of the probes. Most patients, however, feel only a gentle or firm pressure at the points of contact, or the massaging effect of some of the larger, rounded brass electrodes. Contact pads may be taped in place to provide extended stimulation to a specific area in need of prolonged treatment. The patient's hands, feet or other surfaces may be placed in contact with the large brass plates, or they may be treated with a Head Band or Ear Clip set to produce overall body relief or relaxation. Whichever attachment is used with the Electro-Acuscope, the experience of treatment is generally quite comfortable, most often even enjoyable.

Electro-Myopulse: This unique instrument scans individual muscle fibers (multinucleated cells) which



constitute tendons, ligaments or fascia, and facilitates detecting abnormalities in the electrical field, which in turn influences muscle contraction. The instrument monitors actual values or conditions of the treatment area through input electrodes which measure electrical impulses sent from the

brain and spinal cord to the muscles, compares them to normal values, and then adjusts its own specific microcurrent output dosing to bring the parameters monitored in the muscles, to within an optimal range.

The revolutionary Electro-Acuscope and Myopulse were specifically designed to provide today's clinician with an expedient method of treatment for a wide variety of muscle and connective tissue problems.

The beneficial applications include:

- Prevention of retardation of tissue atrophy
- Relaxation of muscle spasm
- Increasing local blood circulation
- Muscle reeducation
- Immediate post-surgical stimulation to prevent venous thrombosis
- Maintaining or increasing range of motion

The effects are physical rather than psychosomatic, and actual improvement can be observed. The Electro-Acuscope is effective in treating acute and chronic conditions, inflammation, edema, and pain. The Myopulse is particularly effective in treating muscle and connective tissue. The two devices are often used sequentially for several conditions.

La Fleur® - Enabling Advanced Applications in Cosmetology and Dermatology

The principles behind the potential benefits of microcurrent therapy in “anti-aging” treatments were explained in the earlier sections. The facial muscles are a group of striated muscles connected to the facial nerve and their contraction and relaxation, controls facial expression.

Pain, psychological stress, and related factors can induce permanent lines on the face. Essentially, the psychosomatic origin of facial lines and wrinkles, and the neuromuscular processes that effect muscle contraction, need to be comprehensively addressed at a fundamental level, to soften their appearance, and achieve relaxation.

La Fleur®, a new generation of intelligent microcurrent instruments enables efficiently addressing the



emotional and psychological component of stress that influences premature aging and facial lines, while helping to relax existing facial lines, wrinkles, and other facial expressions of somatic and psychological stress. The La Fleur Repárer is the latest technological advancement in microcurrent therapy for cosmetic use, works with

the dermis and epidermis in supporting pain management, as well as the reduction in appearance of fine lines and wrinkles on the face and neck, cellulite, stretch marks and scar tissue.

As discussed earlier, microspasms in the muscle fibers and microscars from inflammation are effectively addressed by microcurrent generated and specifically dosed by the instrument, in waveforms based on feedback received from the affected tissue. Thus, carefully modulated microcurrent therapy provides the *'ultimate facial'*, and effectively reduces the signs of skin aging from the inside out.

When used with appropriate accessories, including specially-designed rollers and probes; stress-relieving techniques; and full body massage, the effects can be remarkable. Improvements in skin condition, and the appearance of fine lines, wrinkles, cellulite and scars, can be achieved non-invasively. The overall result is a relaxed and more youthful appearance.

The La Fleur Repárer is the premier system for both producing and maintaining a healthy and more youthful appearance. This system permits facial rejuvenation, repairing the skin and contouring facial muscles, firms and tightens skin and connective tissues in cellulite-affected areas in the body, effects deep tissue massage therapy, and reduces stress through deep relaxation.

Understanding Bioelectrical Impedance Skin Repair and Rejuvenation

Electrical impedance is a measurement of how electrical signals travels through a given material. Every tissue has different bio-impedance determined by its molecular composition. Some materials have high electrical impedance while others have low electrical impedance. Non-compromised muscle tissue has a much higher bio-impedance, or conducts electricity much better than compromised muscle tissue.

An alternating current is used to measure impedance in biological tissues, essentially for two reasons:

- 1) Biological tissue is an ionic conductor. It is known that electrical conduction in a material occurs through charge carriers, which may be electrons, such as is the case for metals, or free ions in suspension in solutions, as is the case for biological tissues. If a direct current is passed through an ionized solution, the phenomenon of polarization occurs very rapidly at the level of each electrode. A double layer of ions is deposited on the electrode, which acts as an insulator and prevents the current from passing. Therefore, a direct current cannot be used to measure the resistance of such a conductor.
- 2) Because it is a heterogeneous conductor that is composed of diversely associated resistive and capacitive elements. Whereas the resistive elements allow an alternating current to pass whatever its frequency, the capacitive elements allow the alternating current to pass only if it has an established frequency.

The therapeutic principle guiding Electro-Acuscope, Myopulse and La Fleur® technology is based on corrective regulation of a tissue, entirely reliant on impedance values collected over a period of time. This is accomplished by using a multiphase sine wave quadrature oscillator that provides both a sine wave and cosine wave output which allows the phase between them to be continuously varied normally between 0 and 180 degrees.

The counter-reaction or response within a fixed period is responsible for detection of the phase lock-in outcome. The two-phase lock-in stage provides the voltage difference between the extremes of oscillation for any pair of orthogonal axis passing through the center of electrode oscillation. The phase is adjusted

so that the voltage difference along the “y” axis corresponds to the “in-phase” output, and that along the “x” axis forms the quadrature output within the prefix amount of time.

This concept allows the tissue to be completely restored, revitalized and refreshed. It is also currently being used to carry healing preparations targeted for specific problems to underlying layers of tissue. This further helps to improve circulation, and results in firmer skin and better skin tone and texture.

Regulatory Classification

In terms of regulatory oversight, Acuscope, and Myopulse and La Fleur® are classified as Class II medical devices by the FDA. TENS devices were marketed in the US before 1976. For purposes of 510(k) decision-making (premarket notification requirements), the term “pre-amendment device” refers to devices legally marketed in the US before May 28, 1976 and which have not been significantly changed or modified since then, and for which a regulation requiring a premarket approval application has not been published by FDA. In the case of next generation devices, based on Acuscope and Myopulse technology, once the FDA determines that a new device is substantially equivalent to a previously marketed (predicate) device, the new device can be legally marketed in the US.

Basic Concepts

Impedance in general terms is a concept dealing with subject of power delivery. In general it provides information about the LOAD being driven by the power source. For example, the output torque of an automobile transmission, the impedance is the output torque divided by the ANGULAR VELOCITY that such torque will sustain.

For a jet engine, the impedance is the thrust (FORCE) divided by the air-speed that such thrust will sustain, and for a fluid pump, the impedance is the pressure it delivers divided by the volume flow rate that such pressure sustains.

In general, impedance is the ratio of a force or other physical IMPOSITION capable of power delivery, to the reaction that such imposition can sustain, where the REACTION is defined such that the product of the IMPOSITION and SUSTAIN REACTION has the units of ENERGY PER UNIT TIME, or power.

For most mechanical systems, a device's impedance varies with the CONDITION of the situation (such as what slope the automobile is climbing, or the VISCOCITY of the fluid being pumped by the PUMP), but an ELECTRICAL IMPEDANCE will either be a constant value or it will depend on the FREQUENCY component of the DRIVING SIGNAL.

Electrical impedance Z is a two-terminal SETUP which transports electrical charge between its terminals at a time-rate I , measured in Coulombs per second (Amperes), such that I is proportional to the voltage V (electrical pressure) applied across the two ELECTRODE terminals. Each circle represents a two-terminal charge pump known as a VOLTAGE SOURCE, which can sustain the electrical pressure given by its indicated voltage V , $E1$ or $E2$.

The value of the impedance is Z , represents the constant of proportionality in the relationship between the voltage V and the current I . This relationship is known as Ohm's Law, which states:

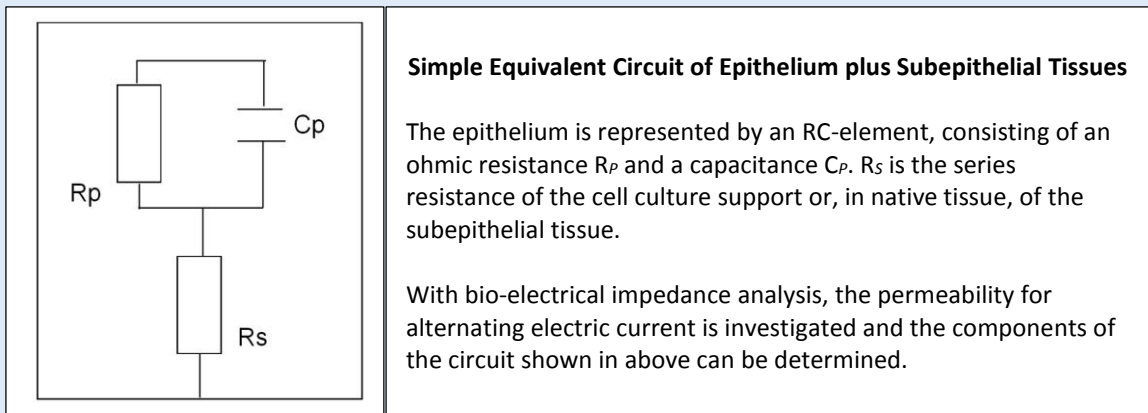
$V = ZI$, where V is the difference in the electrical pressures applied across the two electrode terminals, and Z is measured in Ohms (Volts per Ampere).

The following is an example of a theoretical model originally developed in the twenties to evaluate electrical properties of tissue, that have been used to explain in mathematical terms for those unfamiliar with principles of bio-impedance measurement.

The following basic principle is illustrated in a semicircle model of epithelial bioelectrical bio-impedance and with apical and basolateral membrane.

Equivalent electrical circuit

The electrical properties of an epithelium may, in the simplest way, be represented by the model of an “RC-element”, which consists of an ohmic resistance (R_p) and a capacitor (C_p) in parallel. If the ohmic properties of subepithelial tissue or, in cell cultures, that of support material are to be considered, a series resistance (R_s) is added.



Signature of bio-electrical impedance

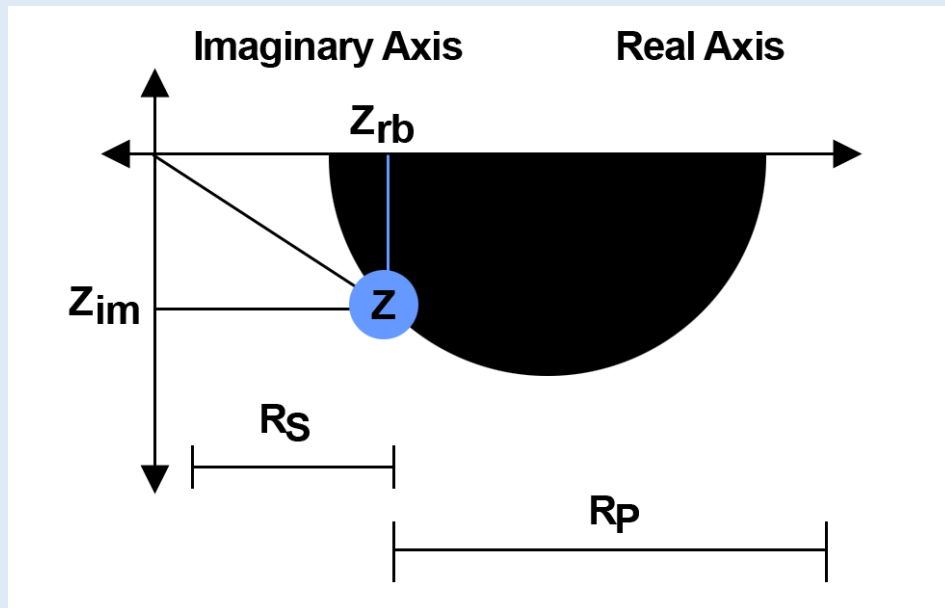
Let us consider an alternating voltage (V) which changes sinusoidally with time (t), $V = V_0 \cdot \sin(\omega \cdot t)$, where V_0 , is the amplitude and ω is the angular velocity. Since the argument of the sine is given in radians, the angular velocity equals $2 \cdot \pi \cdot f$, where f is the frequency of the alternating voltage.

Essentially, the parametric equation of bioelectrical impedance, derived from the following equations that describe a semicircle, covering real (Z_{re}) and imaginary components (Z_{im}), can be graphed in the plane of complex numbers, in a Nyquist plot.

$$Z_{im} = \frac{R_p^2 \cdot C_p \cdot \omega}{1 + \omega^2 \cdot R_p^2 \cdot C_p^2} \tag{1}$$

$$\left(\frac{R_p}{2}\right)^2 = \left(Z_{re} - R_s - \left(\frac{R_p}{2}\right)\right)^2 + Z_{im}^2 \tag{2}$$

The parametric equation of bio-electrical impedance as a function of frequency can be graphed in the plane of complex numbers below. Abscissa and ordinate show real (Z_{re}) and imaginary part (Z_{im}) of the bioelectrical impedance, respectively. The diagram is called a Nyquist plot. (The phase angle of 90° between capacitive and ohmic currents is represented by the orthogonality of the axes of the coordinate systems.)



The impedance locus of the circuit shown in slope above forms a circular arc in the IV quadrant of the coordinate system. R_s and R_p can be derived from the intersections with the abscissa of the extrapolated bio-impedance curve.

From equation 2 it follows that in a Nyquist plot the bio-electrical impedance locus of the equivalent electrical circuit shown in slope 1 describes a circular arc with its center on the abscissa.

The intersections of the bio-electrical impedance curve extrapolated to the abscissa are at $(R_s, 0)$ for $f \rightarrow \infty$ and $(R_s + R_p, 0)$ for $f \rightarrow 0$.

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