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Acuscope, Myopulse and "Next Generation Devices" in Health, Wellness, and Beauty Care:

Background Information and Scientific Rationale



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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, with the advent of the industrial revolution, frictional machines producing electrostatic energy came to be used in such 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, followed by 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 electroacupuncture, pioneered by Berlioz and Sarlandiére, 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 the 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 form of electroacupuncture, 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 that pain intensity is 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 in providing 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.

Closing the gates on pain and accelerating the healing process: The gate control theory and its significance

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, constituted by 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 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 that 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 carries 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 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 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. These channels have now 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 receptor for glutamate that mediates 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 the 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 eample). TENS (transcutaneous electrical nerve stimulation) devices and electroacupuncture (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 in 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 in Sports Injuries:

Physicians who used the Electro-Myopulse in their offices have substantiated its efficacy with anectodal reports and blinded clinical studies (Matheson, 1984). Electro-Myopulse in combination with weight training is reported to provide a safe, effective, non-invasive approach to rehabilitation and improvement of sports performance, in one study by Scott and Picker. Thirty subjects (males 18 to 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 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.

The subjects' hands or feet were placed on grounding plates; 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 (μA) 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 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 overall, general sense of improved well-being. Treatment times ranged from 15 minutes with less severe cases (e.g., knots, muscle spasms) to 30 to 40 minutes in cases of severe muscle

spasms and metabolic imbalance. In the latter case, one marathoner was brought 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 80 in 1978. One remarkable evidence of its benefits was in the case of Freddie Solomon, now 57, who played 11 seasons of football for the 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 Cincinnati 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. Berger hooked up his hand-held electrodes to the Electro-Acuscope 80 and 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 as, and the San Francisco Giants, used the Electro-Acuscope in the 1980's to treat athletic injuries.

Several 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 in 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 the 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 be back again (Miracle Worker?, Eric Olsen).

Lower back pain generated through 'overuse' of back muscles by golfers, has been successfully treated with the Electro-Acuscope/Electro-Myopulse, in the 1980's. A fitness center housed in a trailer was equipped with the instruments and 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 (and therefore called DP), 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, and 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. The Myopulse worked similarly upon connective tissue to produce a state of homeostatis within the involved tissue, by subtle electronic interaction (American Medical News, 1985).

College athletes, such as baseball player Carmel senior Bob Langer, also benefited from the Electro-Acuscope/Myopulse. Langer was injured in a freak accident while at a baseball game. Two players ran into the boards and the Plexiglas popped out. He was three seats down and the glass tilted over on top of his leg, resulting in a broken right fibula that necessitated a cast for six to 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/ Myopulse therapy, and effected the treatment through a hole cut in Langer's cast. Langer was no longer in pain, and was able to play baseball again, and went 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 inflammation to the nerve and muscle with active rest, microcurrent therapy, low-level laser therapy, and cessation of throwing. Minimizing 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 electrostimulation of auricular acupuncture points in the treatment of confirmed post-polio syndrome patients. Short and long term responses in 12 study subjects were measured. Good or excellent results were obtained in all patients; 66.7% reported a return to their pre-existing levels of health. This clinical experience showed 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 discomfort. 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 that their pre-therapy measurements. 82% maintained improved cervical extension/flexion and 77% maintained improved lateral flexion. When the range-of-motion measurements were stratified by pretreatment 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 symptoms improvement form 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 lasting effects. Electro-Acuscope therapy provides a viable alternative. A homeostatis is created in the

autonomic nervous system, as explained earlier in the text, that 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 1930s that all living things are molded and controlled by electro-dynamic fields, which could 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 movement 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 Northorp, 1939; Burr, 1972).

Microcurrents, Electrosleep and Relaxation:

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, 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 to 30 Hertz; Alpha waves associated with a state of conscious physical and mental relaxation, at a frequency of 7.5 to 14 Hertz; Theta waves more at a frequency of 3.5 to 7.5 Hertz, 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 Hertz.

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 to 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, a tranquil state of mind. Outside stimulation usually interrupts this Alpha rhythm. The Theta (3.5 to 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) state Alpha and Theta activity, a condition that is stimulated by electrotherapy with Acuscope/Myopulse, as well.

This non-invasive procedure potentially reduces mental fatigue, enhances autonomic stability, improves concentration and, as a general procedure, to prepares the patient for treatment,

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 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 neuro-muscular 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 hypercontraction 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, that 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 'microscar' that 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 and 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 Ca(2+)-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.

Evidence based research on the role of microcurrent therapies in tissue healing and regeneration:

Microcurrent therapy is essentially a refinement of traditional milliamp electrostimulation 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 μA (microampere) 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.** 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 microamp and used it to study the effects of microcurrents on wound healing rates in 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 was 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 nonstimulated controls. The incorporation of labeled (14C) 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).

No. of Patients	Type & Number of Ulcers	Type of Treatment	Hrs. of Total Treatment Time/Week	Avg. # 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%/wk for controls
76	6: control 100: treatment (inschemic ulcers)	Low intensity D.C. (200-1000 microamp)	42	4.7	30%/wk healing rate vs. 14.7%/wk for controls
30	15: control 15: treatment (indolent ulcers)	Low intensity D.C. (300-700 microamp)	20	5	17.9%/wk healing rate vs. 9% wk for controls
2	Multiple small ulcers	Biphasis pulses 1.5-2 pulses/sec 3-6.5 volts, 200 microsec. Dur.	0.5	2	--
6	6 decubitis ulcers (treatment up to 1 yr)	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 decubitis ulcers	High voltage short duration (50 microsec. Pulses)	3.7	7.3	44.8%/wk

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 the 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 min and then with a current of the opposite polarity for another 11.5 min. 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 function in normal wound healing, in conjunction with ligand-dependant mechanisms. It is 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 guinea pig skin model. They found that voltages across various glabrous (and gland-free) regions of guinea pig skin range from 30 to 100 mV, inside positive; across hairy ones, 0 to 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/cm^2. 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).

Acuscope and Myopulse : An Advancement in Microcurrent Therapy:

This system has been in use by internationally for over 28 years, to address a range of conditions that have their roots in the inflammatory process, including migraine / tension headaches whiplash injury; neck, shoulder, and back pain, TMJ (temopomandipular 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, dermatological conditions, in veterinary practice (equine), and in supporting wound healing are well documented, both by anectodal evidence and controlled clinical studies.

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

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

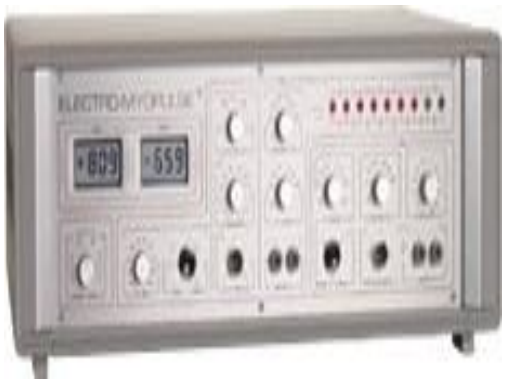
In essence, the system components establish two-way communication between their own internal computer circuits, and the bioelectrical circuits in the area of living tissue being subjected to microcurrent. The waveforms the instruments produce simulate the body's own electrical signals, to overcome the 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.

ElectroAcuscope: This device reads neurological impedance along the linear pathways of current flow (nerves, meridians) and can discriminate points of areas of high and low resistance (acupressure and trigger points). In addition to beneficial effects in pain and inflammation management, the micro-current from the Acuscope also potentially influences the autonomic nervous system with potential benefits in the treatment of stress symptoms and sleep disorders.

The 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 to effect the required polarization in the tissue. The Electro Acuscope causes directed polarization, and the result of the activity in the membranes is 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 relief and report only the sensations of general relaxation, warmth or a comfortable tingling in the area being treated.

The 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 gently 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 headband 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.



ElectroMyopulse: This device scans individual muscle fibers (multinucleated cells) that constitute tendons, ligaments or fascia, and facilitates detecting abnormalities in the electrical field, which in turn influences muscle contraction. The instrument monitors the actual values or conditions of the treatment area, through the input electrodes which measure the electrical impulses sent from the brain and spinal cord to the muscles, compares them to normal values, and then adjusts its own microcurrent output to bring the parameters monitored in the muscles, to within the optimal range.

The modern ElectroAcuscope/Myopulse system was specifically designed to provide today's clinician with an expedient method of treatment of a wide variety of muscle and connective tissue problems. The 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.

A 'New Generation' Myopulse device enables advanced applications in cosmetology/ dermatology:

The principles behind the potential utility 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 the fundamental level, to soften their appearance, and achieve relaxation.

A new generation Myopulse instrument enables efficiently addressing the emotional/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 Myopulse LN is the latest technological advancement in microcurrent therapy for cosmetic use, 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 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.

Using appropriate accessories including specially designed rollers and probes, stress relieving techniques, and full body massage, can be effected. 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.

In terms of regulatory oversight, Acuscope and Myopulse are classified under 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 'preamendment device' refers to devices legally marketed in the U.S. by a firm 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.

The Reparer, MYO75LFR by LaFleur® is the premier system for both producing and maintaining a healthy and more youthful appearance. This system permits facial rejuvenation, repairing and rejuvenating 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 MYO75LFR

Electrical impedance is a measurement of how electrical signal 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, 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 elements 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.

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.

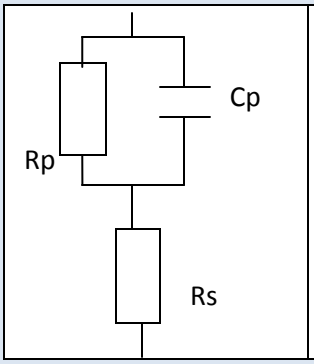
The value of the impedance is Z, represents the constant of proportionality in the relationship between the voltage V and the current I. This relationship is known as Ohm's Law, which states:
V = ZI, where V is the difference in the electrical pressures applied across the two electrode terminals, and 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 capcitor (C_P) in parallel. If the ohmic properties of subepthilelial tissue or, in cell cultures, that of support material are to be considered, a series resistance (R_S) is added



Simple equivalent circuit of epithelium plus subepithelial tissues

The epithelium is represented by an RC-element, consisting of an ohmic resistance R_P and a capacitance C_P. R_S is the series resistance of the cell culture support or, in native tissue, of the subepithelial tissue.

With bio-electrical impedance analysis, the permeability for alternating electric current is investigated and the components of the circuit shown in above can be determined.

Signature of bio-electrical impedance

Let us consider an alternating voltage (V) which changes sinusoidally with time (t),

$V = V_0 \bullet \sin(\omega \bullet t)$

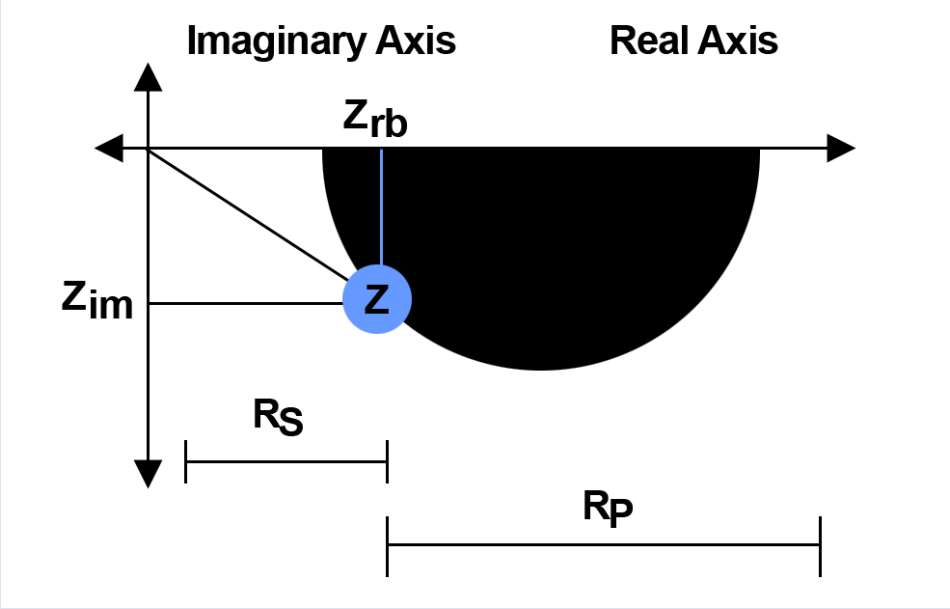
where V_0, is the amplitude and ω is the angular velocity. Since the argument of the sine is given in radians, the angular velocity equals $2 \bullet \pi \bullet f$, where f is the frequency of the alternating voltage.

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.

$$Z_{im} = \frac{R_P^2 \cdot C_P \cdot \omega}{1 + \omega^2 \cdot R_P^2 \cdot C_P^2} \quad (1)$$

$$\left(\frac{R_P}{2}\right)^2 = \left(Z_{re} - R_S - \left(\frac{R_P}{2}\right)\right)^2 + Z_{im}^2 \quad (2)$$

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 $f \rightarrow 0$.

Bioelectrical Impedance, Skin Repair, and Rejuvenation : Guiding Concepts:

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

The counter-reaction or response within a fixed period is responsible for detection of 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 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 completely 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.

References:

1. Alon G, Azaria M, Stein H: Diabetic ulcer healing using high voltage TENS. Phys Ther 66: 775, 1986
2. Alvarez O, et al: The Healing of Superficial Skin Wounds is Stimulated by External Currents ***Journal of Investigative Dermatology***,81:144,1983
3. American Medical News, Pro Golfers Find Fitness Center Helps Them Feel Up To Par, Bill Hofler, 1985
4. Assismacopoulos D: Low intensity negative electrical current in the treatment of ulcers of the leg due to chronic venous insufficiency. A report of three cases. ***Am J Surg*** 115:683-687, 1968
5. Barker AT, Jaffe LF, Vanable JW Jr: The glabrous epidermis of cavies contains a powerful battery. Am J Physiol 242:R358-R366, 1982
6. Barron JJ, Jacobsen WE, Tidd G: Treatment of decubitis ulcers. A new approach, Minn Med 68(2):103-106, 1985
7. Basset C, et al. A non-Operative Salvage of Surgically-resistant Pseudoarthroses and Nonunions by Pulsing Electromagnetic Fields: A Preliminary Report. ***Clinical Orthopaedics and Related Research***;124:128-143, 1977.
8. Becker RO: **The Body Electric**. New York, William Morrow, 1985.
9. Belerdetti, F and Spacey, S. **Voltage-Gated Channels**. Zamperi, G ed. Kluwer Academic/Plenum Publishers, 2005, chapter 15.
10. Biedebach MC. Accelerated healing of skin ulcers by electrical stimulation and the intracellular physiological mechanisms involved. ***Acupunct Electrother Res***. 1989;14(1):43-60.
11. Blitzer A, et al. Botulinum Toxin for the Treatment of Hyperfunctional Lines of the Face. ***Arch Otolaryngol Head Neck Surg.*** 1993 Sep;119(9):1018-22.
12. Burr, HS and Northrop, FSC Evidence for the Existence of an Electro-Dynamic Field in Living Organisms. Proc Natl Acad Sci U S A. 1939 June; 25(6): 284–288.
13. Burr, HS **'Blueprint for Immortality: The Electrical Patterns of Life'**, London, Spearman, 1972
14. Carley PJ, Wainapel SF: Electrotherapy for Acceleration of Wound Healing: Low Intensity Direct Current. ***Archives of Physical Medicine and Rehabilitation***,66:443-446,1985.
15. Carruthers JD, Carruthers JA. Treatment of Glabellar Frown Lines with *C. botulinum*-A Exotoxin. ***J Dermatol Surg Oncol.*** 1992 Jan;18(1):17-21.
16. Casini, A et al. Calcitonin gene-related peptide increases the production of glycosaminoglycans but not of collagen type I and III in cultures of rat fat-storing cells. ***Life Sci***. 1991;49(21):PL163-8.
17. Chee and Walton Treatment of trigger points with microamperage (TENS) –The Electro-Acuscope 80. ***Journal of Manipulative and Physiological Therapeutics***. 9(2):131-134, 1986.
18. Cheng N, et al: The Effect of Electric Currents on ATP Generation, Protein Synthesis, and Membrane Transport in Rat Skin. ***Clinical Orthopaedics and Related Research***, 171:264-272, 1982.
19. Chesterton LS, et al. Transcutaneous Electrical Nerve Stimulation for the Management of Tennis Elbow: A Pragmatic Randomized Controlled Trial: the TATE trial (ISRCTN 87141084). ***BMC Musculoskelet Disord***. 2009 Dec 11;10:156.
20. Davis, P. Microcurrents. **Rehab and Therapy Products Review** Nov –Dec 1992. 62-66.
21. Dubois-Reymond E: **Untersuchungen ueber tierische electrizitaet, Vol II**, Reimer, Berlin, 1860
22. Dumas, M et al. Hydrating Skin by Stimulating Biosynthesis of Aquaporins. ***J Drugs Dermatol***. 2007 Jun;6(6 Suppl):s20-4.

23. Eisenhut, M Change in Ion Transport in Inflammatory Disease. ***Journal of Inflammation*** 2006, 3(5):1-15.
24. Fox AP et al. Kinetic and pharmacological properties distinguishing three types of calcium currents in chick sensory neurons ***J Physiol.*** 1987 Dec; 394:149-72.
25. Fukada, E and Yasuda, I. On the Piezoelectric Effect of Bone. ***J. Phys. Soc. Jpn***. 12 (1957) pp. 1158-1162
26. Gault WR, Gatens PF Jr. Use of Low Intensity Direct Current in Management of Ischemic Skin Ulcers. ***Phys Ther.*** 1976 Mar; 56(3):265-9.
27. Gohar, O. Contribution of Ion Channels in Pain Sensation. ***Modulator*** (19), 2005 9-13.a
28. Gregory, SJ A Holistic Protocol for the Immune System. Progressive Press, 1995
29. H'Doubler, "The treatment of post-polio syndrome with electrostimulation of auricular acupuncture points; an evaluation of twelve patients," American Journal of Acupuncture, 22(1):15-21 (1994).
30. Hinsenkamp M, Bourgois R, Basset C, et al: Electromagnetic Stimulation of Fracture Repair: Influence of Healing on Fresh Fractures. ***Acta Orthopaedics*** (Belgium), 44:671-698, 1978.
31. Holz, GG IV et al. Characterization of the electrically evoked release of substance P from dorsal root ganglion neurons: methods and dihydropyridine sensitivity. ***J Neurosci.*** 1988 Feb; 8(2):463-71.
32. Kaada, B Successful treatment of esophageal dysmotility and Raynaud's phenomenon in systemic sclerosis and achalasia by transcutaneous nerve stimulation. Increase in plasma VIP concentration. Scand J Gastroenterol. 1987 Nov; 22(9):1137-46.
33. Keller JT, Marfurt CF. Peptidergic and serotoninergic innervation of the rat dura mater. ***J Comp Neurol.*** 1991 Jul 22; 309(4):515-34.
34. Kjartansson J et al. Calcitonin gene-related peptide (CGRP) and transcutaneous electrical nerve stimulation (TENS) increase cutaneous blood flow in a musculocutaneous flap in the rat. Acta Physiol Scand. 1988 Sep; 134(1):89-94.
35. Kloth LC, Feedar JA: Acceleration of wound healing with high voltage, monophasic, pulsed current. ***Phys Ther*** 68(4):503-508, 1988
36. Koman, K. The Science of Hurt. **Harvard Magazine**. Nov-Dec 2005:9-13.
37. Lee BY, et al. Ultra-low Microcurrent Therapy: A Novel Approach for Treatment of Chronic Resistant Wounds. ***Adv Ther***. 2007 Nov-Dec; 24(6):1202-9.
38. Lee YM, et al. A Novel Role for the TRPV1 Channel in UV-induced Matrix Metalloproteinase (MMP)-1 Expression in HaCaT Cells. ***J Cell Physiol.*** 2009 Jun; 219(3):766-75.
39. Lembeck F, Holzer P. Substance P as neurogenic mediator of antidromic vasodilation and neurogenic plasma extravasation. Naunyn Schmiedebergs Arch Pharmacol. 1979 Dec; 310(2):175-83.
40. Lennox AJ, et al. Pilot study of impedance-controlled microcurrent therapy for managing radiation-induced fibrosis in head-and-neck cancer patients. ***Int J Radiat Oncol Biol Phys***. 2002 Sep 1;54(1):23-34.
41. Ludwig, A. Results of electromyostimulation therapy in obstructive sleep apnea. Artif Organs. 2008 Aug;32(8):655-8.
42. Matheson, JS. Electro-Acuscope Relieves Pain and Improves Neuromuscular Efficiency, **The Nutritional Consultant & Health Express**, June, 1984,.
43. Maggi, CA et al. GABAA receptor-mediated positive inotropism in guinea-pig isolated left atria: evidence for the involvement of capsaicin-sensitive nerves. ***Br J Pharmacol***. 1989 May;97(1):103-10.
44. Maggi CA et al. Human alpha-calcitonin gene-related peptide-(8-37) as an antagonist of exogenous and endogenous calcitonin gene-related peptide. Eur J Pharmacol. 1991 Jan 3;192(1):85-8.
45. McDonald, A. A Brief Review of the History of Electrotherapy and its Union with Acupuncture. ***Acupunct Med*** 1993;11:66-75
46. Melzack R, Wall PD. Acupuncture and Transcutaneous Electrical Nerve Stimulation. ***Postgrad Med J***. 1984 Dec; 60(710):893-6.
47. Mendonça FA, et al. Effects of the Application of Aloe vera (L.) and Microcurrent on the Healing of Wounds SurgicallyInduced in Wistar rats. ***Acta Cir Bras***. 2009 Mar-Apr; 24(2):150-5.
48. Nessler JP, Mass DP: Direct Current Electrical Stimulation of Tendon Healing *in vitro*. ***Clinical Orthopaedics and Related Research***, 217:303, 1985.
49. Ng MM, et al. The effects of Electro-acupuncture and Transcutaneous Electrical Nerve Stimulation on Patients with Painful Osteoarthritic Knees: A Randomized Controlled Trial with Follow-up Evaluation. ***J Altern Complement Med***. 2003 Oct; 9(5):641-9.
50. Nilsson, J et al DNA synthesis induced by the neuropeptide substance K correlates to the level of myc-gene transcripts. Biochem Biophys Res Commun. 1986 May 29; 137(1):167-74.

51. Omura Y: The relationship between the transmembrane action potential and the voltage-time-dependent, negative resistance characteristics of the voltage-current curves of excitable pacemaker and nonpacemaker cell membranes. ***Transactions of the New York Academy of Sciences***. Series II 33 No. 5:467-518, 1971
52. Omura Y, Lee K, and Jeronimo M: Stimulation of excitable cell membranes by capacitive current and rapidly changing electro-magnetic field without direct contact between electrodes and the cells. Fed proc 31:presented at the annual scientific meeting of the FASEB, Atlantic City, April 14, 1972
53. Omura Y, Lee K: the effects of acupuncture (AC) on cardiovascular and nervous systems, p. 48, Abstracts 2:48 of the 19th Ann Scientific Meeting of the Am Soc for Artificial Internal organs, Boston, Mass, April 7-9, 1973
54. Omura Y: Pathophysiology of acupuncture treatment: effects of acupuncture on cardiovascular and nervous systems. Acup & Electro-Ther Re, int J 1:51-141. 1975
55. Omura Y: Electro-acupuncture: its electro-physiological basis and criteria fir effectiveness and safety – Part 1. Acup & Electro-Ther Res, Int J 1:157-181, 1975
56. Omura Y: Editorial: Simple custom-made disposable surface electrode system for non-invasive "electro-acupuncture" or TNS and its clinical applications including treatment of cephalic hypertension and hypotension syndromes as well as temporomadibular joint problems, tinnitus, shoulder and lower back pain, etc. Acup & Electro-Ther Rest, Int J 6:109-134, 1981
57. Omura Y, Editorial: Non-invasive circulatory evaluation and electro-acupuncture & TES treatment of disease difficult to treat in Western medicine: 1) abnormal brain circulation and blood pressure: cephalic hypertension or cephalic hypotension syndromes and their related conditions—headache, insomnia, blindness due to macular degeneration & retinitis pigmentosa, and some psychiatric problems; 2) severe lower extremity circulatory disturbances with intractable pain, intermittent claudication, ulceration and/or severe diabetic neuropathy**.** ***Acup & Electro-Ther Res***, in J 8:177-225, 1983
58. Omura Y: Electrical parameters for safe and effective electro-acupuncture and transcutaneous electrical stimulation: threshold potentials for tingling, muscle contraction and pain; and how to prevent adverse effects of electro-therapy—Part 1. Acupuncture & Electro-Ther Res, Int J 10:335-337, 1985
59. Omura Y: Electrical parameters for safe and effective electro-acupuncture and transcutaneous electrical stimulation. ***Acup & Electro-Ther Res, Int J*** 10:335-337, 1985
60. Omura Y: Electrical parameters for safe and effective electro-acupuncture and transcutaneous electrical stimulation. ***Acup & Electro-Ther Res, Int J*** 12:335-337, 1985
61. Perney, TM et al. Multiple calcium channels mediate neurotransmitter release from peripheral neurons. ***Proc Natl Acad Sci*** U S A. 1986 Sep; 83(17):6656-9.
62. Pernow, B Substance P--a putative mediator of antidromic vasodilation. ***Gen Pharmacol***. 1983; 14(1):13-6.
63. Riley, Richter: Electrical Skin Resistance Method for Neck and Upper Extremity Pain. ***The John Hopkins Medical Journal,*** 137(2):71-74, August 1975.
64. Robb A, Sajko S. Conservative management of posterior interosseous neuropathy in an elite baseball pitcher's return to play: a case report and review of the literature. ***J Can Chiropr Assoc.*** 2009 Dec;53(4):300-10.
65. Sisken BF, et al. Prospects on Clinical Applications of Electrical Stimulation for Nerve Regeneration. ***J Cell Biochem***. 1993 Apr; 51(4):404-9.
66. Sporn MB, Roberts AB. Transforming growth factor-beta: new chemical forms and new biological roles. ***Biofactors***. 1988 Jan; 1(1):89-93.
67. Stanish W, Gunnfaugson B: Electrical Energy and Soft Tissue Injury Healing. **Sportcare and Fitness**, September/October, 1988, pp12-14
68. Ulett, GA and Wedding, D Electrical Stimulation, Endorphins, and the Practice of Clinical Psychology ***Journal of Clinical Psychology in Medical Settings***, 10(2), June 2003
69. Wolcott LE, Wheeler PC, Hardwicke HM, Rowley BA. Accelerated Healing of Skin Ulcer by Electrotherapy: Preliminary Clinical Results. ***South Med J***. 1969;62(7):795–801
70. Xu FY et al. Effect of Electroacupuncture on the Level of IL-1beta and TNF-alpha in Patients with Osteoarthritis Zhongguo Zhen Jiu. 2009 Jul;29(7):529-31. [Article in Chinese]
71. Yasuda, I Fundamental Aspects of Fracture Treatment, J. Kyoto Med. Assoc. 4: 395, 1953.
72. Zagami, MT et al. Effect of acetylcholine and dopamine iontophoretically applied on the sensory responsive caudate unit**.** ***Arch Int Physiol Biochim***. 1986 Dec; 94(5):305-16.

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