Microcurrent Electrical Neuromuscular Stimulation (MENS)

Introduction of MENS

1. Electrical stimulation therapy and MENS

Microcurrent Electrical Neuromuscular Stimulation (MENS) is being increasingly used throughout the world. Compared with conventional electrical therapy, which utilises electrical current at the milliampere (mA) level, MENS utilises a less intense microampere (µA) current for therapy. This subtle electrical current is below the human threshold of detection and therefore is not felt by the patient.

MENS therapy offers patients the following advantages.

(1) Safe

(2) Comfort

(3) Relief of both acute and chronic pain

(4) Accelerated regeneration of damaged tissues and rapid healing of wounds, cicatrix, and bone fractures

(5) Collagen fiber synthesis, promoting elasticity of the skin

(6) Absence of side effects and complications

2. History of electrical stimulation therapy and MENS

In 1831, Faraday's Faradization technique was heralded as an effective treatment for motor paralysis. Full-scale utilisation of electrical stimulation therapy, however, did not occur until 1840, when it was routinely used in Guys' Hospital in London. In 1902, Ludec of France designed an intermittent direct current unit, which became the basis for modern low-frequency intermittent direct current therapy. Ludee's unit was bulky, difficult to transport, and produced strong, unpleasant stimulation.

Its effectiveness, however, was recognised, and its use became common in the treatment of a variety of acute and chronic diseases during the period from 1920 to 1940, a period when no other effective therapies were available.

Beginning around 1945, the clinical application of electrical stimulation therapy became less popular owing to remarkable progress in pharmacotherapy.

In recent years, again, electrical stimulation therapy, which is virtually free of harmful side effects, is being reevaluated as concern mounts over the side effects of pharmacotherapy.

Therefore, the post war period has seen remarkable progress in the development of instrument for electrical stimulation. Currently, a wide range of equipment is available, offering a variety of choices as to electrical stimulation parameters, including frequency, waveform, pulse length, and interval. This progress in the development of electrical stimulation equipment has, in turn, contributed to an increase in the use of electrical stimulation therapy which is called Transcutaneous Electrical Nerve Stimulation (TENS).

In this circumstance, MENS (Microcurrent Electrical Neuromuscular Stimulation) therapy was developed approximately 20 years ago. This new type of electrical current therapy utilises a faint current, imperceptible to the patient, that still provides a remarkable therapeutic effect. It offers a sharp contrast to conventional units or equipment, whose stimulation is often perceived by patients as uncomfortable or unpleasant.
II. Biological functions of MENS

1. Clinical effects of MENS

A number of clinical effects of MENS have been recognised and reported. The following studies have been excerpted from various research reports.

Lynn Wallace treated more than 600 patients with MENS and examined its clinical effects on pain caused by various disorders of the foot, lower limb, femur, lumbar area, shoulder, elbow, and neck, and found a remarkable sedative effect. According to Wallace, the initial treatment of 15-20 minutes provided some element of pain relief in more than 95% of patients. The extent of pain reduction was an average 55% after the first treatment, 61% after the second treatment, and 77% after the third treatment. The pain was completely disappeared in 82% of patients after less than 10 treatments (four treatments on average).

Double-blind studies are possible with MENS as its stimulation is not discernible by the patient. Lerner and Kirsch conducted a double-blind experiment on 40 patients with chronic low back pain in which patients were randomly allocated to a MENS treatment group and a placebo group that was hooked up to dummy MENS units that provided no electrical stimulation. Stimulation was conducted twice a week for eight weeks. Results showed pain reduction of an average 75% in the MENS treatment group and only 6% in the placebo group.

A number of studies have also found that MENS promotes the healing of wounds and ulcers.

Neil Spielholz studied in animals the effect of MENS on the speed of recovery of an incised ligament. According to the experiment, faint electrical current (approximately 40 U provided the most rapid recovery, an effect that decreased as electrical current increased.

Garley and Wainapel confirmed that the healing of decubitus was accelerated by 150% to 250% through the application of a low 200 - 800 microA current. Gault and Gatens reported a positive effect of MENS in 106 patients with ischemic skin ulcers. In their study, the group treated with MENS using a 200 - 800 microA current recovered approximately twice as fast as the non-treated control group.

It has also been reported by a number of clinicians that the healing of bone fractures is greatly facilitated by low-level electrical current.

The above-mentioned results demonstrate that MENS is markedly effective in treating acute and chronic pain, promotes regeneration of damaged tissues, and heals wounds, cicatrix, and bone fractures.

Cheng and colleagues conducted an interesting experiment to examine the mechanism by which MENS affects physiological functions to promote healing. According to their study, the ATP (adenosine triphosphate) level in the skin tissue of rats was increased approximately 500% by MENS stimulation with a 500 1d A current. In contrast, when MENS with a current above 1,000 microA was applied, ATP generation decreased as the intensity of current increased. The same phenomenon was observed in the active transport of amino acids and protein synthesis. These findings have subsequently been confirmed through experiments by many researchers.
2. Principles of MENS

The functional mechanism of MENS is complicated and has yet to be fully analysed. Although a variety of conflicting theories exist, sufficient research findings have been accumulated that the following conclusions seem justified.

Injury current and the functions of MENS

It has been clear for over a century that an electrical potential of about -50 mV is present in the cell membrane. This potential is known as the resting potential or resting membrane potential. The outer surface carries a positive charge, while the inner surface has a negative charge [Fig.1-1(a)]. When a cell is damaged, the potential of the injured part becomes negative, and electric current flows from the normal to the injured area.

This phenomenon was accurately measured by Matteucci (1938) and Bois-Reymond (1843) and the current is commonly known as "injury current".

![Fig.1-1(a) Resting membrane potential](image)

Note : (+) indicates positive, while (-) indicates negative potential.

Injury current is generated not only when individual cells are injured but also when tissue is damaged. The intensity of the injury current ranges from 10 microA to 30 microA, as demonstrated by experiments. In other words, injury current is a microcurrent.

Injury current is considered to promote the recovery of damaged cells and tissues in the living body. Stimulation by this current is thought to generate ATP and to synthesise protein for the restoration of damaged tissue. Therefore, it can be postulated that artificially generated microcurrent would complement and further promote the natural functions of the injury current.

ATP production, protein synthesis, and active transport.

As mentioned above, MENS increases ATP generation and promotes protein synthesis and the active transport of amino acids. These effects of MENS stimulation have been demonstrated through experimental study. Exactly how these MENS activated changes occur has yet to be determined. However, the recent development of quantum biology has made it possible to make certain inferences, namely, that "electrons" transported to the interior of the body through MENS perform certain functions related to the above phenomena.
It is well known that most of the energy required for muscle contraction, absorption, excretion, and anabolism is supplied through hydrolysis of the high-energy phosphate bond of ATP (adenosine triphosphate). ATP generation is carried out by the electron transport system of mitochondria in the cell. The electron transport system is a group of enzyme systems that transport electrons as well as carrying protons (H' in this case) to couple with oxygen to produce water (H2O).

A simplified example would look like this:

Electrons supplied by glucose are passed through the respiratory enzyme system and delivered to the enzyme at the end.

This means that electrons flow from a high-energy state to a low-energy state. As this change in energy occurs, protons are pumped from the inside of mitochondria to the outside. This creates a proton density gradient in accordance with which protons return to the inside of mitochondria. During this process, protons pass through an enzyme. ATP is synthesised from ADP (adenosine diphosphate) and phosphoric acid by the energy generated during the process. Three ATP molecules are produced per proton, while 36 molecules are produced per glucose molecule.

Protein is mainly synthesised in ribosomes, which are located within the cell. Proteins are macromolecules consisting of up to 20 kinds of amino acids.

During protein synthesis, amino acids are affected in complex ways by electrons.

Further, ion channels in the cell provide a way for N~ and K'+ions to pass through the cell membrane. These channels act selectively, regulating the passage of ions.

**Fig. 1-2 Schematic illustration of ion channel and Na-K pump.**

The cell membrane includes a potassium ion channel that selectively passes N~ ions. Ordinarily, there is a difference in ion concentration between the inside and outside of the cell, as illustrated in Fig. 1-2. Because of this differential, the outside of the cell membrane carries a positive charge and the inside a negative charge. This differential is known as the resting potential or resting membrane potential, as mentioned earlier.

When a cell is stimulated, exciting the membrane, each ion channel opens temporarily. Initially Na+ ions flow into the cell and K'+ions flow out, momentarily reversing the electric
potential. Then the cell rapidly returns to its original state. This change in electrical potential is called the action potential.

The almost immediate recovery of the resting membrane potential after the action potential has been generated is due to the function of an enzyme known as Na\(^+\) - K\(^+\)-ATPase. This enzyme works against the change in ion concentration and, therefore, requires energy. Na\(^+\) - K\(^+\)-ATPase hydrolyzes ATP in the cell.

Utilising the energy generated by hydrolysis, three Na\(^+\) ions are pumped out from the cell while two K\(^+\) ions are pumped into the cell. The physiological activity is known as the Na\(^+\) - K\(^+\) pump. The cell membrane also includes a variety of other ion channels that are related to the active transport of amino acids.

The above-mentioned description of cell physiology is simply meant to demonstrate that electrons are an integral part of many of the complicated chemical reactions occurring routinely in the living body. Calculations indicate that approximately \(6.3 \times 10^{12}\), or 6,300 billion electrons per second are released by a 10 microA current of MENS. This flow of electrons affects the chemical reactions in the living body.

**MENS and the mechanism of pain relief**

It is well known that MENS has a powerful analgesic effect on a variety of conditions. The mechanism by which this analgesic effect occurs is not satisfactorily explained by the gatecontrol theory of TENS (Transcutaneous Electrical Nerve Stimulation), which utilises a mA current, or by an increase in substances such as endorphins and enkephalins created by the body. It is considered that the following two factors are involved.

(A) Generally the MENS current propagates through the blood vessel, where electrical resistance is least. During this process, capillary vessels are stimulated by the flow of electrons, improving blood flow. Concurrently, the decomposition of bradykinin, histamine, and other dolorogenic substances as well as that of lactic acid and other products of fatigue is accelerated. These decomposed products are quickly transported by the blood flow.

(B) In conjunction with the above process, ATP is generated and proteins are synthesised to accelerate recovery of the injured part, resulting in pain relief. The procedure is not carried out to relieve pain, but to heal the injury, thereby alleviating pain as a natural consequence.

Although the above explanation is still hypothetical, sufficient research exists to indicate that it is well founded.

In the case of (A) above, immediate pain relief can be expected, whereas with (B) an extended period of treatment is needed for actual healing to occur.

Various clinical studies indicate that MENS is most effective with parameters of 300 microA or higher output, 1 msec to 50 msec pulse length, and 200 Hz or higher frequency to obtain the effect outlined in (A).

For the more long-term healing described in (B), the most suitable parameters have been found to be 10-200 microA output, 200 msec or higher pulse width, and 0.3-1.0 Hz frequency.

**III Side effects and contraindications**
1. Side effects

MENS causes few adverse side effects. Occasionally, red spots or itching may develop in patients with skin allergies or tender skin at the point where the electrode is placed. In these cases, treatment should be terminated, and the patient referred to a dermatologist. MENS treatment can be resumed after the symptom has been alleviated. Naturally, dose recommendations must be carefully observed.

2. Contraindications

MENS is contraindicated in patients with a cardiac pace maker, those with infectious diseases, fever above WC, pregnant women, the abdomen of menstruating women, the head area, infants and children less than three years of age, and patients judged by a physician to be unsuitable for MENS.

*Remarks:

When applying a pure direct current for a prolonged period, NaCl and H20 react to produce HCl at the positive electrode and NaOH at the negative electrode. This may cause injury to the skin or subcutaneous tissues. To prevent this problem from occurring, recent microcurrent therapy units are designed to automatically alternate polarity at regular intervals. This provides safer, more effective therapy.