ULTRAHIGH FREQUENCY SOUND (ULTRASOUND)

Ultrahigh frequency sound (***ultrasound***) is a form of energy derived from mechanical vibration. It is produced when a crystal set in an ultrasonic transducer is electrically stimulated causing the electrical energy to be changed into a mechanical vibration that produces a focused beam of ultrasonic waves. The waveform can be ***continuous*** or ***pulsed*** (intermittent). The ultrasonic waves pass through a metal cap that covers the crystal (together called the sound head) and, under the right conditions, are passed into biological tissues.

The depth of penetration of ultrasound into the tissues depends on the frequency of the sound (the number of vibrations per second) and the density of the tissues. The therapeutic effects of ultrasound are said to depend on ***frequency***, ***intensity (amplitude)***, and ***duration*** of application.

There are two basic types of ultrasound heads, moveable and stationary. The moveable ultrasound head was developed before the arrival of the ***pulsed waveform***. Because of the heating effect produced by the continuous waveform, comfort dictated that the ultrasound head be continuously moved over a fairly large area (several times the ultrasound head size) to reduce thermal effects on the tissues sounded (the sound head heated up). The pulsed (***intermittently interrupted***) ultrasound waveform does not have the same tissue heating effect and can sometimes be applied with a stationary (fixed) ultrasound head, or with relatively little sound head movement. This allows the ultrasound to be ***concentrated*** in a more concise area. Sound heads vary in size, ranging from four inches to less than one half inch in diameter.

A coupling agent is necessary to conduct the ultrasound from the sound head to the skin because of the minuscule air gap that always exists between the uncoupled sound head and the skin, even when the sound head is firmly pressed against the skin. The coupling agent's job is essentially to seal the sound head and the skin together. The ideal coupling agent should be fluid enough to allow for free transmission of the sound into the skin but viscous enough to prevent run off if it warms up during application. Substances as fluid as mineral oil, or as viscous as soluble colloid gels, have been shown to be adequate couplants.

It is axiomatic that the longer ultrasound passes through a tissue, the greater the ***thermal*** and ***nonthermal*** physiological effects. Application duration of ultrasound in clinical practice usually ranges from four to eight minutes, varying as the size of the treatment site varies. As a rule of thumb, an area varying from 16 to 72 cm^2 is sounded for ***six minutes*** and more than 72 cm^2 for eight minutes. Smaller areas may be sounded for two to four minutes.

Absorption (attenuation) of the ultrasonic beam decreases as the frequency decreases. At ***three megahertz*** (MHz), only 50% of the ultrasonic beam reaches a soft tissue depth of one centimeter (cm), and only 3% reaches a depth of five cm. At ***one MHz*** (the frequency most commonly used by ultrasound units produced in the United States), 82% of the ultrasonic beam penetrates to a soft tissue depth of one cm and 32% reaches five cm.

Intensity (current amplitude) is the amount of power (watts or W) applied to a definitive surface area (per cm^2). Intensities applied therapeutically range from ***0.6 to 2 W/cm^2***. As the intensity of the ultrasound increases, the temperature of the tissues being sounded rises in proportion to the amount of sound absorbed by the respective tissue; the greater the tissue absorption of the sound, the greater the heating. Early researchers found that lower treatment intensities often produced better recipient responses than higher levels. This follows the ***Amd-Schulz Law*** states that low dosages of any form of energy are likely to produce beneficial physiological reactions within stimulated tissues, while medium to high dosages (more than 2.0 W/cm^2) may produce pathological results (heightened sensitivity or pain). Levels ***below 0.6 W/cm^2*** have little or ***no therapeutic value***.

The density of the tissues will affect attenuation of the ultrasound beam. That is, tissues with greater densities cause more attenuation then less dense tissues. The degree of attenuation varies from one type of tissues to another. Blood attenuates the ultrasound beam at a rate of 3% per cm, fat 13%, muscle 24%, blood vessel 32%, skin 39%, tendon 59%, cartilage 68% and bone 96%.

The number of treatments within a given time span plays an important role in the effectiveness of ultrasound treatment. Some authorities have

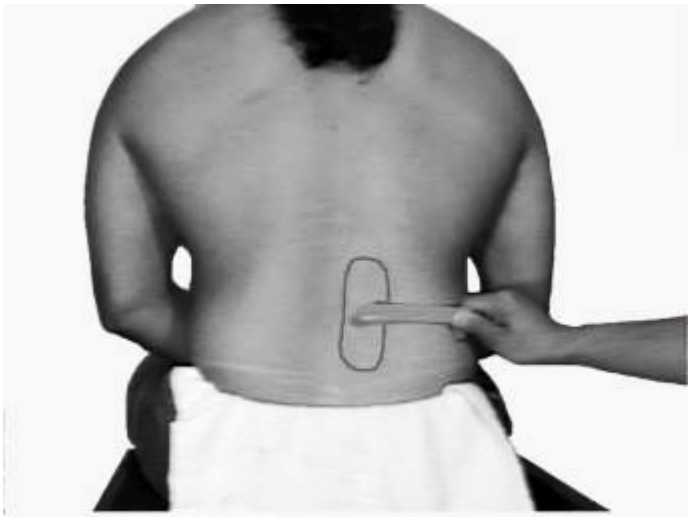
recommended that ultrasound treatment of a given treatment site be conducted as frequently as twice a day (as close as one half hour apart). As a rule, the more frequently a site can be treated, the greater the effect of the ultrasound. It should be noted, however, that different conditions will require a different frequency of treatment. The total number of treatments required for successful resolution will also vary.

Ultrasound can be applied in a ***continuous*** or ***pulsed*** waveform. The ***continuous*** waveform has the greater ***thermal*** effect. It has been reported to be effective at increasing collagen tissue elasticity, altering blood flow, changing nerve conduction velocity, increasing pain threshold and enzyme activity, and changing contractile activity in skeletal muscles. The ***pulsed*** waveform has reportedly been used when the nonthermal mechanisms of ultrasound can be of benefit and when heating needs are minimized (as in the treatment of stasis ulcers). The ***nonthermal*** mechanisms include acoustical streaming, increasing cellular permeability, exertion of a propelling force to drive chemicals across the cell wall barriers, and the dispersion of fluids. The thermal effect of the pulsed waveform is minimized because when in the off-phase of the pulse, the intensity is zero. Any expression of intensity, when speaking of the pulsed waveform, must be an average of the temporal peak value of the intensity and the zero value of the off-phase.

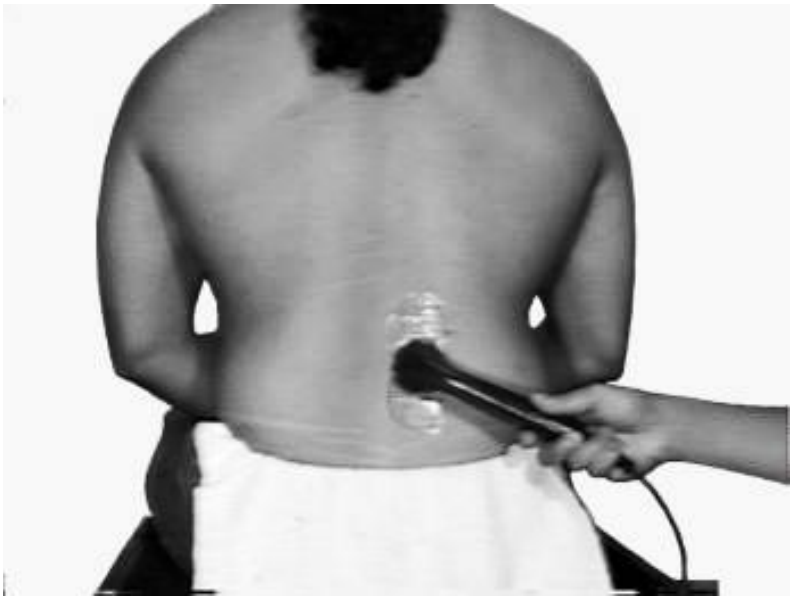
An ultrahigh frequency sound instrument featuring 1 MHz and 3 MHz heads

Application:

- Preset the timer, waveform and dosage levels of the ultrasound machine.
- Liberally apply the coupling agent over the treatment site.
- Place the sound head on the coupling agent covering the treatment site with the flat surface of the sound head against the skin (in bony prominent areas this may only be possible with a small sound head).
- Turn the ultrasound unit on.
- If a moveable sound head and a continuous waveform are being used, move the sound head over the treatment site (being careful to keep the sound head flat against the skin) with a continuous circuitous motion, or with continuous stroking back and forth motion. Move the sound head at a slow, steady rate. If a stationary sound head and a pulsed waveform are used, no motion of the sound head is necessary, but the practitioner should remain in constant attendance and the amplitude adjusted to maintain recipient comfort.
- Following treatment, thoroughly cleanse the sound head in preparation for the next application.



Applying a coupling agent in preparation for Ultrasound treatment



Ultrasounding a treatment site on the low back

Precautions:

Because blood supply to the lens is poor, therapeutic levels of ultrasound ***should not*** be applied over the ***eyeball***. Its poor circulation doesn't allow the heat generated by ultrasound to dissipate adequately and may lead to cataract formation. The retina may also sustain damage from therapeutic levels of ultrasound because any ultrasound entering the eye will be only slightly attenuated by the aqueous and vitreous humors, allowing the ultrasound to have full impact on delicate retinal tissues.

Therapeutic levels of ultrasound ***should not*** be applied over a ***pregnant uterus***. Animal studies have suggested that the temperature elevation produced by an ultrasound beam may cause low birth weight, brain size reduction, and various orthopedic deformities.

Ultrasound applied over the ***testes*** may produce a prolonged elevation of testicular temperature that may result in ***temporary sterility***.

Malignant tissue should not be ultrasounded. In vitro studies have ***suggested*** the possibility that ultrasound may promote malignant cellular detachment and metastasis.

When treating an immature recipient, caution should be exerted to avoid exposing long bone ends to ultrasound because of the remote possibility that the ***epiphysis*** may be damaged by exposure to ultrasound. It should be noted, however, that the literature reviewed suggested that epiphyseal lines are, in fact, safe from normal therapeutic levels of ultrasound. The evidence suggests that only ultrasound intensities ***above 3.0 W/cm^2***, applied with a ***stationary sound head*** for periods of three minutes or more may damage epiphyseal plates and retard bone growth (also true for demineralization of the bone).

Thrombus formations (blood clots) ***should not*** be ultrasounded because of the danger of increasing thrombus formation and promoting ***emboli*** production.

Exercise caution when applying ultrasound to areas that suffer from ***inadequate circulation***. Elevated tissue temperatures may threaten such tissues since the heat transfer normally provided by the circulatory system is missing. In such cases, the ***continuous waveform*** of ultrasound ***should be avoided*** and only the pulsed waveform used and that with caution.

Ultrasound ***should not*** be applied over areas containing ***prosthetic implants*** or other ***hardware***. Any stimulated metal implant may expand from the heat imparted to it by ultrasound. This may cause it to push out against the supporting tissues (bone), only to shrink again when the heat has dissipated, leaving the implant loose within supportive tissues.

As a consequence, the implant may lose its stability and require removal and replacement (if possible).

Early researchers found that lower treatment intensities often produced better patient responses than higher levels. This follows the ***Amd-Schulz law*** that states that low dosages of any form of energy are likely to produce beneficial physiological reactions within stimulated tissues while medium to high dosages may produce pathological results. To put this idea into context, for best results ultrasound should be applied within a relatively low amplitude range of between ***0.6 and 2.0 W/cm^2***. Amplitudes above this range may cause pathological responses, such as heightened sensitivity or pain.

BACTERIAL INFECTION ERADICATION

Very little can be found existing literature reviewed, addressing the issue of using ultrasound for the eradication of bacterial infection. That which can be found leaves the investigator surprised and frustrated over the dearth of information, particularly since what can be found is so provocative. One source reported that ultrasound could be effectively used to depolymerize macromolecules, alter the dispersion and solubility of proteins found in blood serum, inactivate various enzymes (pepsin, hyaluronidase, cycloozygenase), flatten viruses and bacteriophages, destroy yeast cells, and to "punch holes" in a good many bacteria. Other sources report the destructive effects of ultrasonic stimulation on bacteria in studies performed in vitro. No *in-vivo* studies were discovered in the literature reviewed.

Clinical experience has demonstrated that ultrasound may be used to effectively treat isolated bacterial infections generally associated with open wounds, osteomyelitis, abscesses of varying sizes, and ulcers of the skin.

Application:

- Preset the ultrasound unit to deliver a pulsed waveform at 0.8 to 1.2 W/cm² if it employs a frequency of 1 MHz or at 0.8 to 1.8 W/cm² if the unit utilizes 3 MHz.

- Coat the infected area with an appropriate coupling agent (di-alpha tocopheryl oil or a gel containing ibuprofen may be more appropriate than a salt colloidal suspension).

- Continue treatment for six minutes (time based on a treatment area of 72 cm² or less). Treatments should occur daily, or every other day until the lesion closes or symptoms disappear. Success will depend on the sensitivity of the bacteria to the ultrasound. If improvement is not apparent after the first two or three sessions, treatment should be suspended.

- Hygienically cleanse the sound head and dry immediately following application and again before its next use.

Exercise caution when applying ultrasound to areas that suffer from inadequate circulation. Elevated tissue temperatures may threaten such tissues, since the transfer of heat normally provided by the circulatory system is missing. In such cases, the continuous waveform of ultrasound should be strictly avoided and only the pulsed waveform used.

Most successful treatment courses have used the pulsed waveform of ultrasound applied between 0.8 and 1.5 W/cm², for a period of four and six minutes to areas of up to 72 cm². Ultrasound intensity and duration of application variations have depended on patient tolerance. Successful treatment has also been accomplished with the low intensity (0.8 W/cm²) continuous waveform, most notably for the treatment of decubiti and closure of open surgical wounds.

Ultrasound has also demonstrated to be clinically effective in reducing the local effects of some insect bites, including those of the black fly, fire ant, and various spiders. A single treatment session may be enough to reduce the welts and swelling associated with the attendant histamine reaction to the injected poison (toxin), especially if an anti-inflammatory compound is used as the coupling agent (compositions containing ibuprofen have been found to be especially effective). Results suggest that the ultrasound may be effective in denaturing the organic poison involved, thereby preventing possible necrosis.

CALCIUM DEPOSIT MANAGEMENT

Ultrasound has been used successfully for the treatment of calcium deposits or bone spurs (myositis ossificans, joint mice, bone spurs). This treatment generally reduces the patient's apparent pain immediately, producing improved ranges of motion in affected joints and increasing functional abilities.

It has not been firmly established how treatment with ultrasound is able to effect these results. It has been surmised by many, however, that the molecular vibration produced by ultrasound weakens the molecular bonding responsible for ionic calcium deposit formation, essentially dissolving at least part of the formation, and softening rough edges and rounding off sharp points. However, controlled radiographic studies to confirm this premise have not been published. It has also been postulated that the effectiveness of ultrasound treatment lies in its ability to desensitize the tissues surrounding a calcium deposit, effectively accommodating the involved soft tissues to the deposit's presence and raising the pain threshold of these surrounding tissues. Another theory has it that ultrasound simply relieves the pain by reducing the inflammation and interstitial swelling associated with the deposit by increasing circulation in the surrounding tissues (especially if an anti-inflammatory is additionally phonophoresed into the tissues). The truth may be that a combination of these postulates provides the basis for effective ultrasound treatment. Only further study will produce a satisfactory explanation of why ultrasound may be effective.

Clinical experience has suggested that pulsed waveform ultrasound is the most effective form for reducing or managing calcium deposits. Pulsed wave ultrasound can be applied at intensity levels that would ordinarily be painful to the patient if the continuous waveform were used. Additionally, little or no movement of the sound head is necessary when using the pulsed waveform (impossible with the continuous waveform), allowing the sound to be concentrated over the deposit site. Clinical experience has shown that the best results (decreases in pain and restoration of function) are produced by relatively high intensity ultrasound, from 1.5 to 2.0 W/cm² (the intensity should be decreased as patient tolerance decreases).

Application:

- Preset the ultrasound unit to deliver a 1 MHz pulsed waveform at 1.5 to 1.8 W/cm².
- Coat the treatment site with an appropriate coupling agent (a gel containing ibuprofen or a salt colloidal suspension).
- Continue treatment for six minutes (time based on a treatment area of 72 cm² or less). Treatments should occur daily, or every other day until the lesion closes or symptoms disappear. If improvement is not apparent after the six sessions, treatment should be suspended.
- Hygienically cleanse the sound head and dry immediately following application and again before its next use.

CIRCULATION ENHANCEMENT

Ultrasound has been shown by many observers to increase circulation in living tissues. Increases in circulation have most often been attributed to the radiation effect of continuous wave ultrasound, with the correlation usually being drawn between increases in blood flow and tissue temperature.

Although increased tissue temperature and increased blood flow may be correlated in most cases, it does not explain the effect of pulsed ultrasound on microvascular hemodynamics in muscle tissue, as brought to light by fairly recent published research. Small arterioles with lumen diameters of less than 30 micrometers have been shown to temporarily constrict as much as 25%, in normal muscle tissue when ultrasounded by 1 MHz, pulsed ultrasound at 1.25 to 10.0 W^2 (total watts), temporal average-spatial peak, for five minutes. The result is a decrease in single vessel blood flow by as much as 45%, with a consequent venturi effect that may be 20 times greater than normal. These effects could not, however, be duplicated through superficial heating by an equivalent amount. It could be that the vascular response to ultrasound is a reflexive sensory-motor response of the vessels themselves to the ultrasound stimulus.

Whatever the cause, the depression of circulation (albeit temporary) produced by pulsed waveform ultrasound suggests that it may pose a danger to tissues that are already ischemic. Current research has allayed this fear by demonstrating that when pulsed ultrasound is applied to ischemic muscle tissue every other day, for a one to three week period, blood flow improves at the microscopic level without altering the flow or vascular architecture in normal tissue. It has been shown that repeated ultrasound treatment can increase capillary density and promote prolonged vasodilation. The cause of such tissue response is unknown, but it does confirm that pulsed ultrasound can increase tissue perfusion (circulation) in ischemic muscle tissue without relying on the radiation effects of continuous waveform ultrasound.

Pulsed wave ultrasound has been shown clinically to increase peripheral circulation in the distal extremities of individuals suffering from vascular insufficiency (including diabetic patients) over a prolonged series of sessions; it has been especially effective in isolated areas showing signs of isolated breakdown (chronic rubor, swelling and ulceration).

Application:

- Preset the ultrasound unit to deliver a 1 MHz pulsed waveform at 1.2 to 1.5 W/cm^2.
- Coat the treatment site with an appropriate coupling agent (a gel containing ibuprofen or a salt colloidal suspension).
- Continue treatment for six minutes (time based on a treatment area of 72 cm^2 or less). Treatments should occur daily, or every other day until the lesion closes or symptoms disappear. If improvement is not apparent after the first two or three sessions, treatment should be suspended.
- Hygienically cleanse the sound head and dry immediately following application and again before its next use.

Precautions:

Thrombus formations (blood clots) should not be ultrasounded because of the danger of increasing thrombus formation or promoting emboli production.

Exercise caution when applying ultrasound to areas that suffer from inadequate circulation. Elevated tissue temperatures may threaten such tissues since the heat-transference normally provided by the circulatory system is missing. In such cases, the continuous waveform of ultrasound should be avoided and only the pulsed waveform used.

DESENSITIZATION

The perception of pain is dependent on the frequency of afferent sensory nerve firing (the number of impulses per unit of time) and the subject's threshold of pain. Desensitization is dependent on decreasing the intensity of afferent sensory nerve activity and elevating the pain threshold.

Investigators have shown that nervous tissue is sensitive to ultrasound stimulation. In the peripheral nerve, B-fibers have been shown to be most sensitive to ultrasound, with C-fibers more sensitive than A-fibers. Of the fibers classified as subcategories of the A- fiber type, alpha-fibers are the most sensitive to ultrasound, while gamma-fibers are the least sensitive. The A-fibers have the greatest diameter and are the most myelinated while C-fibers are the smallest and the least myelinated. Sensitivity cannot, therefore, be correlated with either nerve size or the degree of myelination. Sensitivity to ultrasound may, instead, be related to the function of the nerve. A-fibers are mostly associated with motor function and motion sense (including the sensory elements from Meissner's corpuscles, Pacinian corpuscles, muscle spindles, Golgi tendon organs and efferent motor nerves). B and C-fibers are associated with autonomic function and sensory nerves (including free pain nerve endings) unrelated to direct motor control or motion sense.

The mechanism of desensitization of the nerve by ultrasounding it is related to how nerve function is affected by such stimulation. Ultrasounding has been shown to be capable of altering nerve conduction velocity as well as influencing how many impulses per unit of time are produced. Ultrasound can increase or decrease nervous activity depending on the amplitude of ultrasound stimulation. Intensities around 0.5 W/cm² tend to increase motor-sensory nerve conduction velocity and the number of volleys per unit of time, sensitizing the nerve. Intensities between 1.0 and 2.0 W/cm² decrease nerve conduction velocity and the number of volleys per unit of time, thereby desensitizing the nerve. Paradoxically, intensities above 2.0 W/cm² (2.1 to 3.0 W/cm²) again increase the nerve conduction velocity and the number of volleys produced per unit of time and sensitizes the nerve.

Studies have shown that ultrasound applied to hypersensitive tissues, at appropriate amplitudes (1.0 to 2.0 W/cm²), and at regular intervals for an extended time, may permanently desensitize the ultrasounded tissue by reducing the sensory nerve's excitability and raising its pain threshold.

The utilization of ultrasound to desensitize soft tissue associated with an adhesion has proven clinically helpful for reducing the pain which soft tissue manipulation may cause.

Application:

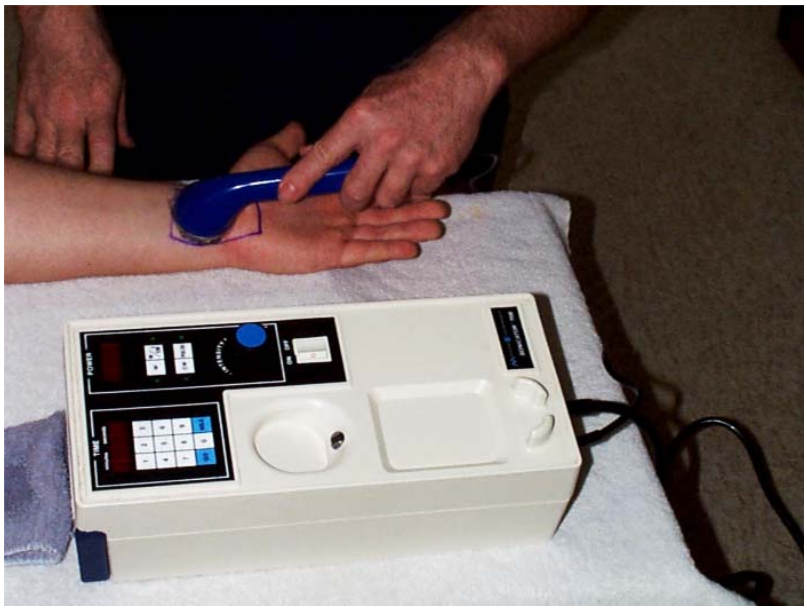
- Preset the ultrasound unit to deliver a 1 MHz pulsed waveform at 1.0 to 2.0 W/cm².
- Coat the treatment site with an appropriate coupling agent (a gel containing ibuprofen or a salt colloidal suspension).
- Continue treatment for six minutes (time based on a treatment area of 72 cm² or less). Treatments should occur daily, or every other day until the lesion closes or symptoms disappear. If improvement is not apparent after the first two or three sessions, treatment should be suspended.
- Hygienically cleanse the sound and dry immediately following application and again before its next use.

INFLAMMATION CONTROL (WITH PHONOPHORESIS)

It has been demonstrated that ultrasound may be used to drive chemicals into living tissues. This process is called phonophoresis. It is thought that ultrasound's demonstrated ability to increase cell membrane permeability may be a major factor in this process, allowing whole molecules of a particular medication (if small enough) to be driven (or absorbed) into the tissues (hydrocortisol is a prime cited example). Additionally, it is thought that increased cell membrane permeability may be augmented by radiation pressure produced by the ultrasound, forcing the medication away from the transducer head into the tissues.

An effect called ***acoustic streaming*** apparently causes the medication forced into the tissues to follow the well-focused ultrasound beam into the tissues, concentrating the medication in the tissues in the path of the beam, with some of the medication ultimately reaching the extreme depth of ultrasound penetration. Following phonophoresis, measurable amounts of hydrocortisone have been recovered from skeletal muscle tissue, at least six cm below the skin.

Population and double blind studies on humans have been performed testing the efficacy of phonophoresis. The results of these tests have varied a good deal. All tests have shown, however, that patient groups suffering from pain demonstrate a statistically higher success rate when treated with anti-inflammatory chemicals, or analgesics, applied through phonophoresis than those groups treated with a placebo and ultrasound, or a placebo and ultrasound at zero intensity. Clinically, the phonophoresis of various medical preparations has been shown to be a safe alternative method for the delivery of concentrated doses of chemical agents without the risk of the infection and pain inherent in percutaneous injections.



Phonophoresing a carpal tunnel

Application:

- Preset the ultrasound unit to deliver a 1 MHz, pulsed waveform, at between 0.8 and 1.5 W/cm².

- Thinly and evenly spread a preparation containing an anti-inflammatory active ingredient over the treatment site.

- Apply the sound head with a light touch, in an even distributing manner. Slowly move the sound head over the treatment site (being careful to keep the sound head flat up against the skin) with a continuous circular motion, or as continuous stroking back and forth motions. Move the sound head at a slow, steady rate. If a stationary sound head and a pulsed waveform are used, the sound head can remain stationary, but you must remain in constant attendance, being careful to maintain the patient's comfort.

- Continue treatment for six minutes (assuming an area less than or equal to 72 cm²).

- Daily treatment is advisable until your treatment goals are reached**.**

Of the techniques explored to date, by far the most effective means of relieving soft tissue inflammation has been shown to be the phonophoresis of anti-inflammatories directly into affected tissues.

Of the anti-inflammatory medical preparations commonly used in phonophoresis for the treatment of soft tissue inflammation, hydrocortisone is the best known. Its beneficial effects include its ability to decrease cell membrane permeability, thereby preventing further bradykinin and other irritant components (the precursors of prostaglandin) from being released from the cell, and its ability to stabilize lysosome bodies. These attributes aside, corticosteroid treatment can contrarily increase inflammation and soft tissue irritation (after all, it is not a "human" product, but rather bovine). Consequently, the author is less than enthusiastic about using hydrocortisone for phonophoresis due to the uncertainty of its direct effect on the condition.

Some practitioners have begun to treat human inflammations with the phonophoresis of various salicylates. These are generally selected for their ability to retard the formation of prostaglandins, through the inactivation of cyclooxygenase, an enzyme that converts fatty acids into concurrent interstitial swelling. Clinical experience has shown this treatment to be effective, but comparatively slow.

The phonophoresis of di-alpha tocopheryl (vitamin E) reportedly provides the effect of decreasing cell membrane and capillary bed permeability (providing much of the beneficial effect expected of hydrocortisone) with the added facility of suppressing histamine production and relieving venule constriction (claudication). This treatment provides fairly rapid relief of pain and helps reduce the corticosteroids without the dangers to renal function posed by the salicylates. Phonophoresis of di-alpha tocopheryl has also been found to be useful in increasing the healing rate of open wounds and reducing scar formation.

Ibuprofen in topical form has been clinically shown to be superior to all the other abovementioned chemicals for stopping the inflammation process when sonicated into irritated tissues. It does this by halting the production of prostaglandins**.**

INFLAMMATION CONTROL (WITHOUT PHONOPHORESIS)

Clinical studies on humans have established that ultrasound alone is not an effective treatment of soft tissue inflammation. Indeed, several double blind controlled studies have demonstrated that ultrasound alone is no more effective than sham ultrasound (the placebo) in the treatment of inflammation. Indeed, other data would seem to indicate that ultrasound used alone might be considered contraindicated for the treatment of inflammation. One of the factors that make ultrasound effective for phonophoresis is its ability to increase cell membrane permeability. Its application may therefore be more likely to spread inflammation by causing the "leaking" of inflammatory chemicals (bradykinin, histamine and prostaglandins) into adjacent soft tissues, thereby spreading the inflammation. This may be a bit “far-fetched”, but worth considering in lieu of more definitive research.

Considering the above, and having clinically studied the lack of positive results from applying ultrasound applied (without an anti-inflammatory coupling agent) to relieve inflammation, it is the author’s opinion that such treatment is a waste to time and effort (except possibly for a placebo effect). As a consequence, no regime for application is offered here.

INSECT BITE NEUTRALIZATION

Clinical experience has shown that ultrasound can be utilized to denature the toxin injected into the skin by fire ants, and various *non-poisonous* spiders (it may actually have a similar effect on poisonous bites, but the opportunity to try it has not yet arisen).

Such an insect bite is characterized by a red or white swelling around or in close association with a single or double puncture mark, usually discernible to the naked eye or through a magnifying glass. In some cases, the tissues themselves may be necrosed, and the bite site is a ragged hole in the skin. The patient will usually complain of a severe itching or burning pain, in and around the bite site. If the bite is just proximal of a distal extremity (hand or foot), there may be generalized swelling distal to the bite.

Application:

- Preset the ultrasound unit to deliver a 1 MHz or 3 MHz, pulsed waveform, at between 0.8 and 1.8 W/cm².

- Thinly and evenly spread a preparation containing an anti-histamine active ingredient over the treatment site, and then covered by a sonicator gel or an anti-inflammatory gel (topical ibuprofen is recommended).

- Apply the sound head with a light touch, in an evenly distributing manner. Slowly mover the sound head over the treatment site (being careful to keep the sound head flat up against the skin) in continuous circle motions, or as continuous stroking back and forth motions. Move the sound head at a slow, steady rate. If a stationary sound head and a pulsed waveform are used, no motion of the sound head is necessary, but you should remain in constant attendance, being careful to maintain the patient's comfort.

- Continue the treatment for six minutes (assuming an area of 72 cm²).

- Treat daily until treatment goals are reached**.** Usually only one or two sessions are necessary to relieve the patient's symptoms, including the pain and swelling.

WOUND HEALING

Fairly recent, *in vivo* research has demonstrated that ultrasound can be used to stimulate the production of granulation tissue (specifically in trophic ulcers) as well as collagen and acid soluble non-collagenous protein synthesis in scar tissue. It can increase the growth rate of replacement tissue at the site of injury and increase the rate of protein synthesis in fibroblasts. Indeed, it has been shown that the rate of DNA synthesis in regenerating tissue is accelerated by exposure to ultrasound. Clinically (by way of confirmation), ultrasound has been shown to be of immense value for the facilitation of the scar tissue formation required for complete wound healing and final closure, especially when applied to healing resistant surgical incisions or pressure sores (decubiti).

The mechanisms at work that promote synthesis of scar tissue when exposed to adequate levels of ultrasound are still only postulated, but it is thought that the nonthermal effects of ultrasound may be responsible for the facilitation of the required protein synthesis.

Application:

- To facilitate scar tissue formation, and retard or eradicate bacterial infection, coat the wound with a suitable coupling agent (di-alpha tocopheryl oil may be preferable to colloidal gels) before ultrasound is applied.

- Preset the ultrasound unit to deliver a 1 MHz or 3 MHz, pulsed waveform, at between 0.8 and 1.8 W/cm², for six to eight minutes (assuming the treatment area to be 72 cm² or less).

- Treat once or twice daily (there should be a 30-minute rest between applications, at the very least), until the wound has closed and no underlying infection is evident.

It has been found that using di-alpha tocopheryl (vitamin E) oil as a coupling agent increases the effectiveness of ultrasound for the facilitation of the healing process. Di-alpha tocopheryl has the effect of slowing down the healing process to allow for better granulation and of facilitating orderly collagen (scar tissue) formation. The collagen tends to lie down in parallel fashion rather than at random, making for smaller, more elastic scars. It also seems to reduce the tendency to produce keloid formations in keloid prone patients (those keloids which do develop are less pronounced and far less rigid).

Precautions:

Avoid ultrasounding thrombus formations (blood clots) because of the danger of increasing further thrombus formation or promoting emboli production.

Exercise caution when applying ultrasound to areas which suffer from inadequate circulation. Such tissues may be threatened by elevated tissue temperatures, since the heat transfer normally provided by the circulatory system is missing. In such cases, avoid the continuous waveform of ultrasound in favor of the pulsed waveform.

Exercise caution in the selection of active ingredients to be phonophoresed. Concern yourself with the side effects that may result from exposure to medical preparations containing any steroid (cortisone or cortisol), especially in excess. Besides the systemic side effects that may occur from corticosteroid treatment, phonophoresis of corticosteroids has been noted (in humans) to cause a transient increase in pain in some subjects (reportedly occurring in 10.6% of the cases seen). Such pain may begin eight to 12 hours after application and last for two to 12 hours after onset. After the pain subsided, the majority of patients were judged to have improved. This response is similar to the phenomenon noted as an infrequent secondary effect of corticosteroid percutaneous injection.

Any of the salicylates or ibuprofen may be of concern if the particular patient suffers from renal insufficiency (salicylates and ibuprofen must be excreted through the kidneys to be eliminated from the human system). Such a prohibition should continue until research has established that the phonophoresis of salicylates or ibuprofen is harmless for a patient suffering from renal insufficiency or prone to renal failure.

References

W.T. Coakley, "Biophysical Effects of Ultrasound at Therapeutic Intensities", *Physiotherapy*, 64:6, June 1978. Pp. 166-168

M. Dyson, J.B. Pond, J. Joseph, and R. Warwick, "Stimulation of Tissue Regeneration by Pulsed Plane-Wave Ultrasound", *IEEE Transactions on Sonics and Ultrasonics, July 1970. Pp. 133-139*

M. Dyson and J. Suckling, "Stimulation of Tissue repair by Ultrasound: a Survey of the Mechanisms Involved", *Physiotherapy*, 64:4, 1978. Pp. 105-108

C.S. Enwemeka, "The Effects of Therapeutic Ultrasound on Tendon Healing", *Am J Phys Med Rehabil*, vol. 68, 1989. Pp. 283-287

B.H. Ferguson, *A Practitioners Guide to the Ultrasonic Therapy Equipment Standard*, U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration, Rockville, Maryland, July 1985.

G.T. Haar, "Basic Physics of Therapeutic Ultrasound", *Physiotherapy*, 64:4, April 1978. Pp. 100-104

A. Hartley, Therapeutic *Ultrasound,* Anne Hartley Agency, Etobiocoke, Ontario, 1987.

J.F. Lehmann, B.J. DeLateur and D.R. Silverman, "Selective Heating effects of Ultrasound in human beings", *Archives of Physical Medicine and Rehabilitation*, June 1966.

F.E. Miller and J.B. Weaver, "Ultrasound Therapy", *The Physical Therapy Review*, 34:11, 1954. p. 562

E.M. Oakley, "Application of Continuous Beam Ultrasound at Therapeutic Levels", *Physiotherapy*, 64:6, June 1978. Pp. 169-172

D.C. Reid and G.E. Cummings, "Efficiency of Ultrasound Coupling Agents", *Physiotherapy*, 63:8, August 1977. Pp. 255-257

H.P. Schwan and E.L. Carstensen, "Advantages and Limitations of Ultrasonics in Medicine", *JAMA*, vol. 149, May 1952. Pp. 121-125

Therapeutic Ultrasound, Reprinted from *Physiotherapy*, March/April, 1987, Journal of the Chartered Society of Physiotherapy, London, England.

F.S. Zach, B. Boynton, K. Phillips, and E. Smith, "Localized Application of Ultrasonic Energy", *British Journal of Physical Medicine*, August 1957.

M.C. Ziskin and S.L. Michlovitz, "Therapeutic Ultrasound", *Thermal Agents in Rehabilitation*, F.A. Davis Co., Philadelphia, Pa., 1986. Pp. 141-157

Bacterial Infection Eradication

J. Burgos, J.A. Ordonez, and F. Sala, "Effect of Ultrasonic Waves on the Heat Resistance of Bacillus Cereus and Bacillus Licheniformis Spores", *Applied and Environmental Microbiology*, vol. 24, 1972. Pp. 497-498

W.T. Coakley, "Biophysical Effects of Ultrasound at Therapeutic Intensities", *Physiotherapy*, vol. 64 (4), June 1978. Pp. 166-168

M. Dyson, J.B. Pond, J. Joseph, R. Warwick, "Stimulation of Tissue Regeneration by Pulsed Plane-Wave Ultrasound," *IEEE Transactions on Sonics and Ultrasonics*, July 1970. Pp. 133-139

M. Dyson, J. Suckling, "Stimulation of Tissue repair by Ultrasound: a Survey of the Mechanisms Involved", *Physiotherapy*, vol. 64 (4), 1978. Pp. 105-108

F.E. Miller, J.B. Weaver, "Ultrasound Therapy," *Phys Ther Rev*, vol. 34 (11), 1954. p. 562

J.A. Ordonez and J. Burgos, "Effect of Ultrasonic Waves on the Heat Resistance of Bacillus Spores," *Applied and Environmental Microbiology*, 32:1, July 1976. Pp. 183-184

H.P. Schwan, E.L. Carstensen, "Advantages and Limitations of Ultrasonics in Medicine", *JAMA*, 149, May 1952. Pp. 121-125.

Unsigned, "Ultrasonic Energy in Medicine*", International Record of Medicine and General Practice Clinics*, 168:12, December 1955. Pp. 803-806

Calcium Deposit Management

W.T. Coakley, "Biophysical Effects of Ultrasound at Therapeutic Intensities," *Physiotherapy*, vol. 64

G.T. Haar, "Basic Physics of Therapeutic Ultrasound", *Physiotherapy*, vol. 64 (4), April 1978. Pp. 100-104

F.E. Miller, J.B. Weaver, "Ultrasound Therapy", *Phys Ther Rev*, vol. 34 (11), 1954. p. 562

E.M. Oakley, "Application of Continuous Beam Ultrasound at Therapeutic Levels", *Physiotherapy*, vol. 64 (6), June 1978. Pp. 169-172

H.P. Schwan, E.L. Carstensen, "Advantages and Limitations of Ultrasonics in Medicine", *JAMA*, 149, May 1952. Pp. 121-125

M.C. Ziskin, S.L. Michlovitz, "Therapeutic Ultrasound*", Thermal Agents in Rehabilitation*, F.A. Davis, Philadelphia, Pa., 1986. Pp. 156-157

Circulation Enhancement

M. Dyson, C. Franks, and J. Suckling, "Simulation of Healing of Varicose Ulcers by Ultrasound", *Ultrasonics*, vol. 14, 1976. Pp. 232-236

A.B. Galitsky and S. Levina, "Vascular Origin of Trophic Ulcers and Application of Ultrasound as Preoperative Treatment of Plastic Surgery", *Acta Chir. Plastic,* 6:4, 1964. Pp. 271-278

R.D. Hogan, K.M. Burke, and T.D. Franklin, "The Effect of Ultrasound on Microvascular Hemodynamics in Skeletal Muscle: Effects During Ischemia", *Microvascular Research*, vol. 23, 1982. Pp. 370-379

J.F. Lehmann, *Therapeutic Heat and Cold*, The Williams & Wilkins Co., Baltimore, Md., 1982. Pp. 512-515

B.J. Paul, C.W. Lafratta, A.R. Dawson, E. Babb and F. Bullock, "Use of Ultrasound in the Treatment of Pressure Sores in Patients with Spinal Cord Injury", *Arch. Phys. Med. Rehabil.*, vol. 41, 1960. Pp. 438-440

Desensitization

W. Bierman, "Ultrasound in the Treatment of Scars", *Arch. Phys. Med. & Rehab.,* vol. 35, 1954. p. 209

W.C. Farmer, "Effect of Intensity of Ultrasound on Conduction of Motor Axons", *Physical Therapy*, 48:11, 1968. Pp. 1233-1237

J.E. Griffen, "Physiological Effects of Ultrasonic Energy as It is Used Clinically", *Journal of the American Physical Therapy Association*, vol. 46, 1966. Pp. 18-26

D. Rubin and J.H. Kuitert, "Use of Ultrasonic Vibration in the Treatment of Pain Arising from Phantom Limbs, Scars and Neuromas: A Preliminary Report", *Archives of Physical Medicine & Rehabilitation*, July 1955. Pp. 445-452

I. Tepperberg and E.J. Marjey, "Ultrasound Therapy of Painful Post-Operative Neurofibromas", *Am. J. Phys. Med.,* vol. 32, 1953. p. 27

M.C. Ziskin and S.L. Michlovitz, "Therapeutic Ultrasound*", Thermal Agents in Rehabilitation*, F.A. Davis Co., Philadelphia, Pa., 1986. Pp. 157-158

Inflammation Control (with Phonophoresis)

T.J. Antich, "Phonophoresis: The Principles of the Ultrasonic Driving Force and Efficacy in Treatment of Common Orthopaedic Diagnosis*", The Journal of Orthopaedic and Sports Physical Therapy,* 4:2, Fall, 1982.

Bauernfeind JC, Newmark H, and Brin M, "Vitamins A and E Nutrition Via Intramuscular or Oral Route", *Amer J Clin Nutr*, 27, March 1974. Pp. 234-253

H.A.E. Benson, J.C. McElnay, R. Harland, "Use of Ultrasound to Enhance Percutaneous Absorption of Benzydamine", *Physical Therapy*, 69:2, February 1989. Pp. 113-118

M.H. Cameron, L.G. Monroe, "Relative Transmission of Ultrasound by Media Customarily Used for Phonophoresis", *Physical Therapy*, 72:2, February 1992. Pp.142-148

C.D. Ciccone, B.G. Leggin, J.J. Callamaro, "Effects of Ultrasound and Trolamine Salicylate Phonophoresis on Delayed-Onset Muscle Soreness", *Physical Therapy*, 71:9, September 1991. Pp. 666-678

J.P. Davick, R.K. Martin, J.P. Albright, "Distribution and Disposition of Titrated Cortisol Using Phonophoresis", *Physical Therapy*, 68:11, November 1988. Pp. 1672-1675

H.P. Ehrlich, H. Tarver, T.K. Hunt, "Inhibitory Effects of Vitamin E on Collagen Synthesis and Wound Repair", *Annuls of Surgery*, Feb, 1972. Pp. 235-240

Goodson JM, Dewhirst FE, and Brunetti A, "Prostaglandin E2 Levels and Human Periodontal Disease", *Prostaglandins,* 6:1, April 10, 1974. Pp. 81-85

J.E. Griffin, "Physiological Effects of Ultrasonic Energy as It is Used Clinically*", Journal of the American Physical Therapy Association*, vol. 46, 1966. Pp. 18-26

J.E. Griffin, J.L. Echternach, and R.E. Price, "Patients Treated with Ultrasonic-driven Hydrocortisone and with Ultrasound Alone", *Physical Therapy*, vol. 47, 1967. Pp. 549-601

J.E. Griffin and J.C. Touchstone, "Effects of Ultrasonic Frequency of Phonophoresis of Cortisol into Swine Tissue", *American Journal of Physical Medicine*, 51:2, 1972. Pp. 62-78

J.E. Griffin, J.C. Touchstone, and A. C-YLiu, "Ultrasonic Movement of Cortisol into Pig Tissues", *American Journal of Physical Medicine*, 44:1, 1965. Pp. 20-25

J.S. Halle, R.J. Franklin, and B.L. Karalfa, "Comparison of Four Treatment Approaches for Lateral Epicondylitis of the Elbow", *Journal of Orthopaedic and Sports Physical Therapy,* 8:2, August 1986. Pp. 62-69

M. Kamimura, "Anti-inflammatory Activity of Vitamin E", *Journal of Vitaminology*, 18, 1972. Pp. 204-209.

J.A. Kleinkort and F. Wood, "Phonophoresis with 1% Versus 10% Hydrocortisone", *Journal of the American Physical Therapy Association*, vol. 55, 1975. Pp. 1320-1324
K. McKean, "Pain", *Discover*, October 1986. Pp. 82-92

M.A. Moll, "A New Approach to Pain-Lidocaine and Decadron with Ultrasound", *USAF Med. Serv. Digest*, vol. 30, May/June, 1977. Pp. 8-11

H. Rubenstein, "Ultrasonic and Corticosteroid Absorption", *Podiatry Quarterly*, No. 2, 1963.

W. Smith, F. Winn, R. Parette, "Comparative Study Using (4) Modalities in Shin Splint Treatments", *Journal of Orthopaedic and Sports Physical Therapy*, 8:2, August 1986. Pp. 77-80

M. Shodell, "The Prostaglandin Connection", *Science 83*, March 1983. Pp. 78-82

H.T.G. Williams, D. Fenna, R.A. Macbeth, "Alpha Tocopheryl in the Treatment of Intermittent Claudication", *Surgery, Gynecology, & Obstetrics*, April 1971. Pp. 662-666

M. Wing, "Phonophoresis with Hydrocortisone in the Treatment of Temporomandibular Joint Dysfunction", *Physical Therapy*, 62:1, January 1982. Pp. 30-31

M.C. Ziskin and S.L. Michlovitz, "Therapeutic Ultrasound*", Thermal Agents in Rehabilitation*, F.A. Davis Co., Philadelphia, Pa., 1986. Pp. 141-157

Inflammation Control (Without Phonophoresis)

D.S. Downing, "Ultrasound Therapy of Subacromial Bursitis", *Physical Therapy,* 66:2, February 1986. Pp. 194-199

M.K. Inaba and M. Piorkowski, "Ultrasound in Treatment of Painful Shoulders in Patients with Hemiplegia", *Physical Therapy,* vol. 52, 1972. Pp. 737-741

E. Mueller, S. Mead, et al., "Symposium on Ultrasonics: A Placebo Controlled Study of Ultrasound Treatment for Periarthritis", *American Journal of Physical Medicine,* vol.33, 1954. Pp. 31-35

M.P. Roman, "A Clinical Evaluation of Ultrasound by Use of Placebo Technique", *Physical Therapy Review,* vol. 40, 1960. Pp. 649-652

Wound Healing

M. Dyson, J.B. Pond, J. Joseph, and R. Warwick, "Stimulation of Tissue Regeneration by Pulsed Plane-Wave Ultrasound", *IEEE Transactions on Sonics and Ultrasonics*, July 1970. Pp. 133-139

M. Dyson and J. Suckling, "Stimulation of Tissue repair by Ultrasound: a Survey of the Mechanisms Involved", *Physiotherapy*, 64:4, 1978. Pp. 105-108

H.P. Ehrlich, H. Tarver, T.K. Hunt, "Inhibitory Effects of Vitamin E on Collagen Synthesis and Wound Repair", *Annuls of Surgery*, February 1972. Pp. 235-240

J.E. Griffin, "Physiological Effects of Ultrasonic Energy as It is Used Clinically", *Journal of the American Physical Therapy Association*, vol. 46, 1966. Pp. 18-26

F.E. Miller and J.B. Weaver, "Ultrasound Therapy", *Physical Therapy Review*, 34:11, 1954. p. 562

E.M. Oakley, "Application of Continuous Beam Ultrasound at Therapeutic Levels", *Physiotherapy,* 64:6, June 1978. Pp. 169-172

H.P. Schwan and E.L. Carstensen, "Advantages and Limitations of Ultrasonics in Medicine", *JAMA,* vol. 149, May 1952. Pp. 121-125

Therapeutic Ultrasound, Reprinted from Physiotherapy, March/April, 1987, *Journal of the Chartered Society of Physiotherapy*, London, England.

F.S. Zach, B. Boynton, K. Phillips, and E. Smith, "Localized Application of Ultrasonic Energy", *British Journal of Physical Medicine*, August 1957.

M.C. Ziskin and S.L. Michlovitz, "Therapeutic Ultrasound", *Thermal Agents in Rehabilitation*, F.A. Davis Co., Philadelphia, Pa., 1986. Pp. 141-157