

Electrotherapy Simplified



4th Edition

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Foreword
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JAYPEE

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Recent Advances in Electrotherapy

SOME IMPORTANT POINTS IN THIS UNIT

- ◆ Targeted radiofrequency therapy (transfer of energy through capacitive and resistive methods) transfers high frequency electromagnetic energy at a frequency of 500 kHz, through the tissues of the body creating selective tissue hyperthermia.
- ◆ This radiofrequency alternating current when applied to the tissues induces movement of ions, increases the activity of lymphatic system, induces vasodilatation, produces muscle relaxation, and increases supply of nutrients and oxygen to tissues, producing therapeutic benefits.
- ◆ The term “shockwave” denotes a high-energy sound wave that terminates in a bursting of energy similar to a mini-explosion.
- ◆ A shockwave is essentially a pressure disturbance that propagates rapidly through a medium.
- ◆ Extracorporeal shockwave therapy (ESWT) is a new technology using shockwaves to treat chronic, painful conditions of the musculoskeletal system. The term extracorporeal denotes, the shockwaves are produced out side the body.
- ◆ Shockwave is a noninvasive, nonelectrical high energy sound wave that passes through the body via a handheld probe.
- ◆ Shockwaves are different from other acoustic waves because they are at a lower frequency.
- ◆ Extracorporeal shockwave therapy (ESWT) was first used in early 1980s, as a noninvasive treatment, to eliminate kidney stones, a process known as lithotripsy.
- ◆ Shockwave therapy is subdivided into two types, such as radial shockwave therapy (RSWT) and focused shockwave therapy (FSWT).
- ◆ In physiotherapy, use is made of radial/soft shockwave.
- ◆ Shockwaves, when applied to pathological states of musculoskeletal system, produce the effects through tissue destruction, enhancement of biological processes, and pain reduction.
- ◆ High tone therapy device is a new device with a unique characteristics of electrotherapy and its main effects for the body are entering energy into the body to revitalize the body and normalize tissue metabolism and cell function.
- ◆ High-tone therapy, also known as high-tone external muscle stimulation (HTEMS) is a type of electrotherapy that uses an alternating electric field to stimulate the body's cells and tissues.
- ◆ High-tone external muscle stimulation (HTEMS) delivers up to 5,000 mW energy with frequencies between 4,096 Hz and 32,768 Hz into the body.
- ◆ The time duration of high tone therapy can be up to 60 minutes, and more than 1 channel (usually 4 channels) can be used simultaneously.

- ◆ Class IV hot laser therapy (high intensity laser therapy/high power laser therapy) with power output >500 mW can treat a variety of musculoskeletal conditions. It creates heat on the surface of the skin due to higher power density (irradiance).
- ◆ Cryo air device blows cold air (at -32°C) over the site of pain and inflammation to produce therapeutic benefits.
- ◆ Transcranial magnetic stimulation (TMS) is a noninvasive brain stimulation modality based on the principles of electromagnetic induction, producing long-term neuromodulation in certain brain areas.
- ◆ Transcranial direct-current stimulation (tDCS) is a portable, wearable brain stimulation technique that delivers a low electric current to the scalp. A fixed current between 1 and 2 mA is typically applied. tDCS works by applying a positive (anodal) or negative (cathodal) current via electrodes to an area. tDCS is a neuromodulation technique that produces immediate and lasting changes in brain function.
- ◆ Virtual reality is defined as a “computer-based technology that allows users to interact with a multisensory simulated environment and receive ‘real-time’ feedback on performance”.
- ◆ Biofeedback is a type of mind-body technique used to control some of the body's functions, such as the heart rate, breathing patterns and muscle responses.
- ◆ Robotic devices deliver high dosage and high intensity training to patients with motor disorder caused by stroke/cerebral palsy. The device can be used to provide therapy to restore function or as a compensatory device to assist function.
- ◆ Functional electrical stimulation (FES) is a treatment that applies small electrical charges to a muscle that has become paralyzed or weakened, due to damage in the brain or spinal cord (UMN diseases).
- ◆ Hyperbaric oxygen therapy as a treatment in which a patient intermittently breaths 100% oxygen, while the treatment chamber is pressurized to a pressure greater than sea level.
- ◆ Betar sound therapy produces musical sound which affects pulse rates, skin temperature, blood pressure, muscle tension and brain wave activity.
- ◆ Vibroacoustic therapy involves combination of low frequency sound, and relaxing music played through speakers, built into bed or chair to achieve physical and psychological therapeutic goals.
- ◆ Matrix rhythm therapy provides pulsations in the frequency of 8–12 Hz (normal pulsing frequency of cells), to synchronize and reset the disturbed cell rhythm, helping to relax muscles and acceleration of regeneration and healing.
- ◆ Magnetic field therapy: Magnetic field therapy uses different types of magnets on body, either using a static magnetic field or electromagnetism to produce therapeutic benefits. In this therapy the body is exposed to low frequency magnetic field, causing production of a weak electrical current giving the therapeutic benefits.

There has been a general trend over the last few years, for the energy levels applied in electrotherapy to be reduced. Ultrasound treatment doses are significantly lower (in terms of US intensity and pulse ratios) than previously thought to be effective. Pulsed shortwave employs power levels which are several orders of magnitude lower than those applied during continuous shortwave therapy. Low level laser therapy is another such example of the clinical application of low energy levels to damaged, irritated or traumatized tissues.

The over-riding principle of these interventions, is that the application of a low power/energy modality can enhance the natural ability of the body to stimulate, direct and control the healing and reparative processes. Instead of ‘hitting the cells’ with high energy levels, and thereby forcing them to respond, the low energy applications are aiming to tickle the cells, to stimulate them into some higher activity level and thus use the natural resources of the body to do the work. One area of interest is to potentially take the applied energy to really low levels

(microcurrent type therapies) and deliver a current to the tissues that is remarkably similar to the endogenous currents that appear to be physiologically effective.

A review on electrophysical agents (EPA 1990–2010) found that in the last 20 years, ultrasound availability and usage show increasing trends in several countries. Pulsed shortwave diathermy and laser have shown growing trends. TENS, interferential, and biofeedback availability and usage have shown an increase in the UK and decrease in Australia and the Republic of Ireland. Continuous shortwave diathermy availability and use are declining in all countries in the study and a steep decline occurred in microwave diathermy also. Even though, there is no documented evidence of SWD, MWD, LWD, producing harmful effects, these modalities are gradually disappearing from electrotherapy units, requiring adequate research in this area, to specify, whether or not to use such modalities, which were very much used by physiotherapists in the past. Microcurrent therapy, extracorporeal shockwave therapy, low intensity pulsed ultrasound (LIPUS), low and high intensity laser and some new radiofrequency (RF) applications such as targeted radiofrequency therapy, etc., are currently an emerging group of electrophysical agents. These are briefly discussed below:

TARGETED RADIOFREQUENCY THERAPY

Targeted radiofrequency therapy (transfer of energy through capacitive and resistive methods) transfers high frequency electromagnetic energy at a frequency of 500 kHz, through the tissues of the body creating selective tissue hyperthermia. It has been scientifically proven to bring therapeutic effects such as immediate and intense pain relief, muscle relaxation, edema reduction, and supporting tissue regeneration and healing.

■ PHYSIOLOGICAL EFFECTS OF TARGETED RADIOFREQUENCY THERAPY

This therapy is a noninvasive therapeutic method based on interaction of radiofrequency current with the biological structures. The radiofrequency current is transferred to the body through the contact surface of the applied electrodes. Dissipation of the current leads to selective tissue temperature increase and results in effects such as pain relief, myorelaxation, increase of local blood circulation, and edema reduction. It can be used for treatment of both acute and chronic disorders of musculoskeletal system, such as muscle spasms, joint degenerative disorders, back pain, and soft tissue injuries.

The radiofrequency alternating current when applied to the tissue induces movement of ions, increases the activity of the lymphatic system (helping in edema reduction, increased toxin and metabolite absorption, absorption of inflammatory exudates) induces vasodilatation (increases blood perfusion), produces myo-relaxation (helping in reduction of pain and muscle spasm), and increases supply of oxygen and nutrients (helping in tissue healing).

■ THERAPEUTIC EFFECTS OF TARGETED RADIOFREQUENCY THERAPY

Muscle Relaxation

The effect of the targeted radiofrequency therapy on the hypertonic muscle fibers is to cause their immediate relaxation of the muscle. The effect of muscle relaxation is primarily based on vasodilatation, which occurs immediately during the therapy and is responsible for higher supply of nutrients into the tissue.

Uses: Local muscle spasm, spasm in low back pain/neck pain.

Tissue Regeneration and Healing

The improvement of tissue metabolism is a natural and valuable secondary outcome of the therapy. It leads to faster healing of the traumatized soft tissue and faster resorption of post injury hematomas.

Uses: Post-traumatic hematoma, muscle injury (for muscle regeneration).

Edema Reduction

The walls of the arterioles are enlarged and the precapillary sphincters relaxed by the effect of the current, allowing increased local blood perfusion. This leads to an increase of the lymphatic processes (drainage), venous drainage and subsequently to reduction of the edema.

Use: Post-traumatic edema.

Pain Relief

The effect of the targeted radiofrequency therapy on pain relief results from muscle relaxation, edema reduction, tissue regeneration, and healing.

Uses: Low back pain, neck pain, carpal tunnel syndrome, tendinitis, myalgia, joint pain (gonarthrosis/knee arthrosis).

■ CONTRAINDICATIONS OF TARGETED RADIOFREQUENCY THERAPY

- ❖ Pregnancy
- ❖ Tissues infected with tuberculosis or other forms of virulent bacteria
- ❖ Serious cardiac or respiratory insufficiency
- ❖ Acute inflammations
- ❖ Sensation disorders (anesthesia, hypoesthesia, or hyperesthesia in the area of application)
- ❖ Skin inflammations, trophic skin changes in the area of application, irritated or damaged skin
- ❖ Bleeding conditions, hemorrhagic disorders, menstruation

- ❖ Regions of known or suspected malignancy (neoplasia, patients undergoing radiotherapy)
- ❖ Overall cachexia (weight loss) of any etiology
- ❖ Febrile conditions of any etiology
- ❖ Infections
- ❖ Metal objects or active implantable medical devices in the place and path of the application (pacemaker, endoprosthesis, splints and bolts, etc.)
- ❖ Application over endocrine glands and gonads
- ❖ Area of large sympathetic plexuses
- ❖ Peripheral nerves close under the skin surface
- ❖ Small infants.

■ POSSIBLE SIDE EFFECTS OF TARGETED RADIOFREQUENCY THERAPY

The patient may get some unpleasant sensation over the treated area, which is usually temporary. There might occur moderate skin irritation.

■ METHOD OF APPLICATION OF TARGETED RADIOFREQUENCY THERAPY

Two different electrodes (capacitive and resistive) of the targeted radiofrequency therapy provide precise and effective treatment at any tissue level. The capacitive electrode focuses the therapy into muscle layers. The resistive electrode targets tissue with higher impedance such as muscular insertions, tendons, and bone surfaces.

Step by Step Therapy

- ❖ **Locate the disorder:** Use appropriate diagnostic method to locate the area to be treated.
- ❖ Apply the conductive cream sufficiently over the area to be treated and over the area, where neutral electrode will be placed.
- ❖ Select the electrodes, viz., active electrode (capacitive/resistive) and neutral electrodes (metallic/adhesive single use).

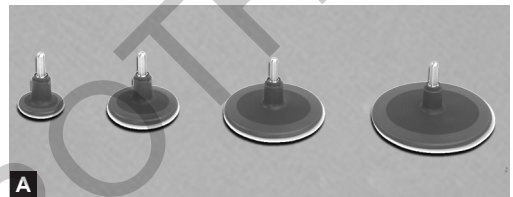
- ❖ Place the neutral electrode, in close proximity to the treated area.
- ❖ Select the therapeutic protocol from the displays on the touch screen, provided by the manufacturer (e.g., BTL6000 TR Therapy Elite touch screen displays the therapeutic protocol) and apply treatment (**Figs. 20.1A to C**). Tecar therapy sessions can last from 5 to 60 minutes, and the frequency of treatment depends on whether the condition is acute or chronic.
- ❖ **Use of capacitive mode:** For the first phase of treatment, the capacitive electrode, which targets the superficial muscle tissue are used (**Figs. 20.2A and B**).
- ❖ **Use of resistive mode:** For the second phase of treatment, the resistive mode, which selectively affects the muscular and fibrous insertions, located deeper within the tissue are used.



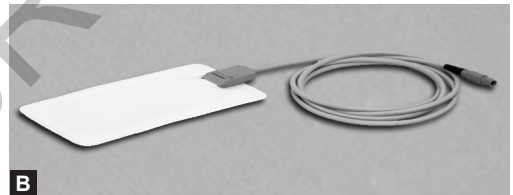
Fig. 20.1A: Targeted radiofrequency therapy machine.



Fig. 20.1C: Targeted radiofrequency therapy to low back (paravertebral muscles) (For color version, see Plate 6).



A



B

Figs. 20.2A and B: (A) The active electrodes; (B) The neutral electrode.

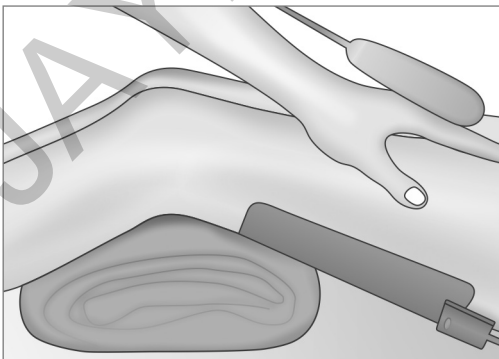


Fig. 20.1B: Targeted radiofrequency therapy to quadriceps.

The preset therapeutic protocols serve only as a guide or a therapy proposal and by no means can they replace the professional consideration and experience from the clinical practice. Besides, selecting the preset treatment parameters, the physiotherapist should collect evidences on treatment parameters for various conditions, and apply the same to patients for better therapeutic result (if any).

SHOCKWAVE IN PHYSIOTHERAPY

The term “shockwave” denotes a high-energy sound wave that terminates in a bursting of energy similar to a mini-explosion. It is essentially the same as a super-sonic jet breaking the sound barrier and creating

an energy force strong enough to shatter windows. ESWT utilizes a high peak pressure ranging from 5 MPa to 130 MPa. This unique form of energy leads to rapid initial rise in pressure amplitude (500 bar) over short life cycle of less than 10 ns.

A shockwave is essentially a pressure disturbance that propagates rapidly through a medium. A clinically useful shockwave is effectively a controlled explosion (Ogden et al., 2001), and when it enters the tissue, it gets reflected, refracted, transmitted, and dissipated like any other energy form. Just like an ultrasound wave, the shockwave consists of a high pressure phase followed by a low pressure (or relaxation) phase. When the shockwave reaches a boundary, some of the energy gets reflected and some gets transmitted.

These are supersonic waves (waves that travel with a speed greater than the speed of the sound in a medium are called supersonic waves) with unusually large amplitude. Shockwaves are different from other acoustic waves because they are at a lower frequency.

HISTORY OF SHOCKWAVES

Shockwaves were initially employed as a noninvasive treatment for kidney stones (1970–1980), and it has become a first-line intervention for such conditions. Subsequently, a series of experimental investigations, performed to find the effect of this energy on bones, ligaments, tendons, capsules, etc., led shockwaves as an intervention for the recalcitrant lesions of these tissues. At present, the clinical uses have expanded to include wound management, fracture treatment, etc. By early 1990, reports came regarding clinical benefits of shockwave for treatment of calcific tendinitis and for other disorders of tendon, ligament, etc.

SHOCKWAVE THERAPY/ EXTRACORPOREAL SHOCKWAVE

Extracorporeal shockwave therapy (ESWT) is a popular noninvasive therapeutic modality in

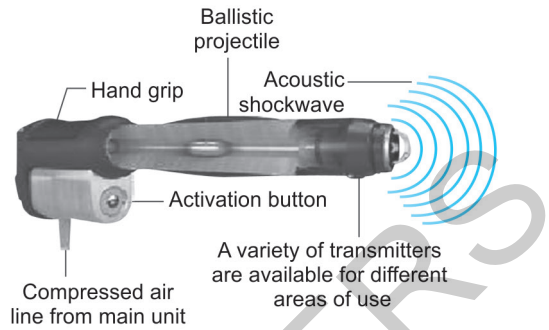


Fig. 20.3: Probe showing emission of shockwaves.

the medical field for the treatment of numerous musculoskeletal disorders. The therapy uses high-intensity pulsed mechanical waves to treat musculoskeletal disorders and it does not produce a thermal effect.

Extracorporeal shockwave therapy (ESWT) is a new technology using shockwaves to treat chronic, painful conditions of the musculoskeletal system. A shockwave is an intense, but very short energy wave traveling faster than the speed of sound. The word “extracorporeal” means “outside the body” and refers to the fact that the shockwaves are generated outside the body.

It is a noninvasive, nonelectrical high energy sound wave that passes through the body via a handheld probe (Fig. 20.3). The shockwaves produce a rapid increase in blood circulation to the target area and will break down fibrous scar tissue which builds up over time, especially with chronic conditions.

There are two fundamentally different types of shockwaves (McClure and Merritt 2003).

Nonfocused also Called Radial or Dispersive (Soft/Low Energy Shockwave)

This is created by mechanical concussion that creates expanding wave fronts away from the concussion plate (the end of the machine) which travel forward into the body. These waves rapidly attenuate after their generation

(Ammendolia et al., 2001; McClure and Merritt 2003).

Focused/High Energy Shockwave (Hard Shockwave Often Referred to as Lithotripsy)

High energy shockwave has been shown to have detrimental effects on soft tissues. It normally requires some form of local analgesia to tolerate the treatment although there have been studies demonstrating that the use of local analgesia can be a negative factor to the outcome of shockwave. High energy shockwave is unlikely to be used in the therapy settings where most clinicians have low energy shockwave machines.

SHOCKWAVE—PRINCIPLES OF PRODUCTION (AFTER CHUNG AND WILEY 2002)

There are basically four different ways to produce the “shockwave,” which without getting technical about it are: spark discharge; piezoelectric; electromagnetic; and pneumatic (or electrohydraulic) (Fig. 20.4). The wave that is generated will vary in its energy content and will also have different penetration characteristics in human tissue.

In therapy, the most commonly employed generation method is based on the pneumatic

system, and the key reason for this is that a radial (dispersive) wave results. The focused waves are essential for “surgical” interventions, but given their destructive nature, they are less appropriate for therapeutic uses. Focused waves are sometimes also referred to as “hard” shockwaves and the radial or dispersive wave sometimes called a “soft” shockwave.

Mechanism of Action of Shockwaves in the Tissues

When clinically effective shockwaves enter the body, they have been described as creating “controlled explosions” (Ogden et al., 2001). However, more correctly, when a shockwave enters living tissue, it will either be reflected, refracted, transmitted, or dissipated, just like any other wave. Therapeutic ESW energy is released at the tissue interfaces of different impedance values. What that means is that where there is a change in structure, part of the shockwave energy will be released and creates compression and shear loads on the surface of the material with the greater impedance. This rapid interaction between compression and shear forces results in what is commonly referred to as cavitation. As cavitation bubbles collapse, they create smaller, secondary energy waves known as microjets. These microjets also create a lot of force that also breaks down pathological deposits of calcification in the soft tissues through direct, mechanical means.

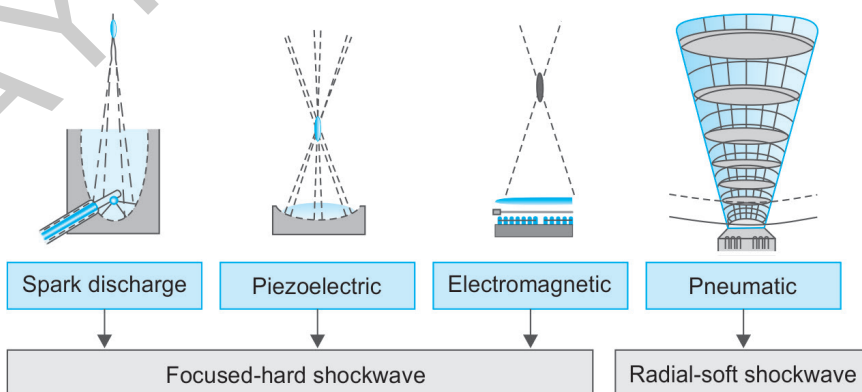


Fig. 20.4: Production of different types of shockwaves.

Shockwave exerts a mechanical pressure and tension force on the afflicted tissue. This has been shown to create an increase in cell membrane permeability, thereby increasing microscopic circulation to the tissues and the metabolism within the treated tissues, both of which promote healing and subsequent dissolution of pathological calcific deposits.

Beyond breaking down pathological calcification deposits, ESWT has been shown to stimulate cells in the body known as osteoblasts. These bone cells are responsible for bone healing and new bone production, so stimulating them obviously enhances the healing process of bone. The benefit of ESWT is attributed to its effect on bone remodeling. **Martini and colleagues** showed that low-energy SWT (14 kV and 0.15 mJ/mm²) increases osteoblastic (i.e., bone tissue formation) activity, while high-energy SWT (28 kV and 0.40 mJ/mm²) increases osteoclastic (i.e., bone tissue is broken down) activity. Some investigators suggest that ESWT could be useful for patients with pathological bone formation. **Brissot and colleagues** noted that ESWT reduced pain, improved range of motion and walking distance, and alleviated the need for an assistive device in patients with heterotopic ossification of various origins. **Lohrer and associates** found similar results in a population of adolescents with Osgood–Schlatter syndrome (a condition characterized by excessive bone growth). Biological responses to shockwaves, such as resolution of inflammation, neovascularization, and angiogenesis, may also play important roles in clinical heterotopic ossification treatment.

ESWT shockwaves have also been shown to stimulate fibroblasts. Fibroblasts are the cells responsible for the healing of connective tissues such as tendon, ligaments, and fascia.

ESWT also diminishes pain, which is expected to occur in two ways:

1. ESWT initially diminishes pain through what is known as hyperstimulation anesthesia. This is where the nerves

sending signals of pain to the brain are stimulated so much that their activity diminishes, thereby decreasing or eliminating pain. This effect is usually (but not always) short lived.

2. ESWT is also believed to diminish pain over longer periods of time through the stimulation of what is known as the “gate-control” mechanism, where nerves can be stimulated to “close the gate” to pain impulses sent to the brain.

Physiological Effects of Shockwave Therapy

Acoustic waves generated by the shockwave trigger biological effects which lead to faster and long-term healing and regeneration of the tissue. There is temporary anesthetic effect, from the hyperstimulation of the tissue from the ESWT. The patient may experience effects like tingling, aching, redness, or bruising, which are relatively rare, modest, and short-lived. The breakdown of scar tissue is the key to why shockwave therapy is so effective. Unlike normal elasticated tissue, scar tissue is nonelastic and will prevent normal movement and function, thereby weakening the unaffected tissue surrounding it, often causing further damage and pain. By increasing circulation and breaking down scar tissue, shockwave therapy will stimulate cell regeneration and promote normal healing and rapid reduction of pain. The normal function can then be restored. The following are the most strongly established effects of therapeutic shockwave at tissue levels:

- ❖ Mechanical stimulation
- ❖ Increased local blood flow
- ❖ Increase in cellular activity—release of substance P, prostaglandin E₂, and almost certainly other inflammatory cytokines
- ❖ Transient analgesic effect on afferent nerves.
- ❖ Breakdown calcific deposits (primarily, but not exclusively in tendon).

Therapeutic Effects and Uses

Shockwaves, when applied to pathological states of musculoskeletal system, produce the effects through the followings:

- ❖ Destruction of tissue (e.g., treatment of heel spurs)
- ❖ Increased biological effects (healing, blood supply, etc.)
- ❖ Pain reduction.

Considering the above treatment effects of this modality, shockwave therapy can be applied to the following conditions:

- ❖ Plantar fasciitis: A study done by Anup Krishnan and Yogesh Sharma in 2012 on the effects of extracorporeal shockwave therapy in plantar fasciitis patients, reveal significant beneficial effect.
- ❖ Shoulder pain, e.g., calcific lesions of the rotator cuff and bony spurs
- ❖ Lateral epicondylitis (tennis elbow)
- ❖ Medial epicondylitis (golfer's elbow)
- ❖ Patellar tendinitis (jumper's knee)
- ❖ Tibial stress syndrome (shin pain)
- ❖ Achilles tendinitis
- ❖ Hip pain
- ❖ Heel pain, heel spurs
- ❖ Chronic neck dysfunction due to thick myofascial bands/trigger points.

Contraindications

- ❖ Treatment over chest and upper back to avoid damage to lungs.
- ❖ Growing epiphysis in children.
- ❖ Hemophiliacs and patients on anticoagulant therapy.

- ❖ Malignancy.
- ❖ Metal implants on bone may not be a contraindication; however, metals in other organs, such as a prosthetic heart valve is a contraindication.
- ❖ Cemented prosthetic joints.

Precaution

Infection: Infections in local area should be treated with full caution to prevent spreading of infection.

Adverse effects: If the energy applied is within therapeutic range, no adverse effect is expected. However, any pain or discomfort caused during or after treatment is expected to disappear after 1–2 days. There can be a minor skin irritation or paresthesia, which is usually temporary.

DOSAGE OF THERAPEUTIC SHOCKWAVE

Shockwaves are divided in terms of their energy (**Fig. 20.5**) content and although there is some controversy, it is generally accepted that the following groups would be reasonable (after Rompe et al., 1998):

- ❖ Low (up to 0.08 mJ/mm^2)
- ❖ Medium (up to 0.28 mJ/mm^2 —though some authorities elect for a higher value)
- ❖ High (over 0.6 mJ/mm^2).

Treatment Dose Issues

- ❖ **Energy level:** Low (up to 0.08 mJ/mm^2) and possibly the medium (up to 0.28 mJ/mm^2) energy levels are used in therapy.

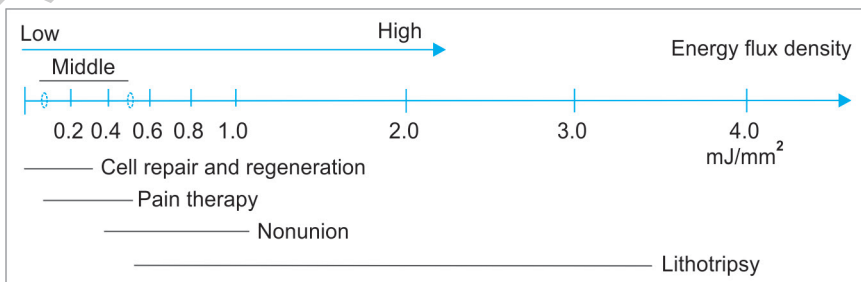


Fig. 20.5: Principal energy division of shockwave in medical practice.

- ❖ **Number of shocks:** Shock number is usually between 1,000 and 1,500, though some authorities suggest up to 2,000. 1,000–1,500 has been used in the clinical trials with the best (most significant) outcomes.
- ❖ **Number of treatment session repetitions:** Typically 3–5 sessions appear to be effective for the majority of patients, spaced such as to let the tissue “reaction” at least partly subside from the first session before the next treatment is delivered. However, the research evidences regarding optimal treatment spacing, should be considered during treatment applications.

Techniques of Application

Select the machine (**Fig. 20.6**). The part to be treated is cleaned like any other electrotherapy procedures. A shockwave gel/ultrasound gel is applied over the site and the transmitter head is positioned over the site of pathology (**Fig. 20.7**). The dosage in terms of energy flux density and number of shocks are applied as per the desired effect.

The following factors may be considered for application of treatment, as well as research:

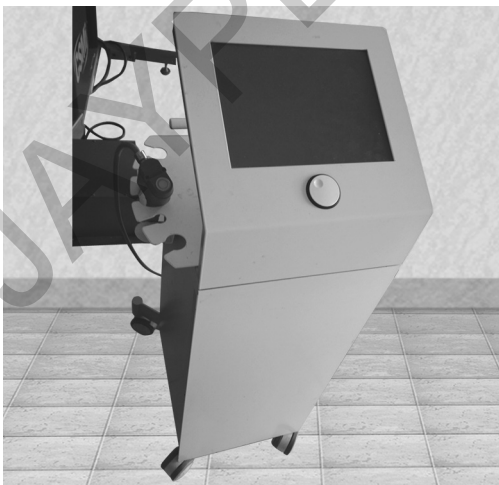


Fig. 20.6: The shockwave therapy apparatus.



Fig. 20.7: Application of shockwave therapy for plantar fasciitis (For color version, see Plate 6).

Overall Energy

The total energy applied to the tissues can be calculated, considering the shock head size and the amount of energy given to the shock (mJ/mm^2 or bar) and the total number of shocks. For example, if the shock head size is 1 mm and the amount of energy given to the shock is $0.18 \text{ mJ}/\text{mm}^2$, and the total number of shocks is 2,000, then the total energy density (total energy applied to the tissues) will be: $0.18 \text{ mJ}/\text{mm}^2 \times 2,000 \text{ shocks} = 360 \text{ mJ}/\text{mm}^2$.

Frequency of Shockwaves

The effect of changing the frequency of shockwave therapy known as the pulse rate frequency may be more than just for comfort. Higher frequencies 14+ Hz are described by patients as feeling easier. Lower frequencies 8–12 Hz are often described as feeling more painful. It has been suggested for using higher frequencies at the beginning of treatment to familiarize or acclimatize the patient to the sensation then work down to the desired frequency in stages, e.g., 200 shocks at 16 Hz then 200 at 14 Hz then 200 at 12 Hz aiming for 10 Hz in the end for the desired 1,000 shocks.

Size and Shape of Treatment Head

Radial shockwave is produced across the face of a shockwave head. These heads vary in size and shape. The most commonly used heads are 15 mm across and are described as convex (the head reaches a peak in the center which is higher than the edges). A head with a physically smaller diameter will give more

energy at the same power setting than a head with a bigger diameter, e.g., a 30 mm head will deliver 60 mJ across a wider area thus spreading the force compared to a 15 mm head. A 6 mm head will deliver all of the 60 mJ into a smaller space; hence, the energy level in that space will be higher. For this reason, power of the shockwave is expressed as mJ/mm².

■ HI-TONE THERAPY

High-tone therapy, also known as high-tone external muscle stimulation (HTEMS) is a type of electrotherapy that uses an alternating electric field to stimulate the body's cells and tissues.

High tone therapy device is a new device with a unique characteristics of electrotherapy and its main effects for the body are entering energy into the body to revitalize the body and normalize tissue metabolism and cell function. Similar to conventional electrical stimulation, that stimulates nerves and muscles, tissue metabolism can be affected using hi-tone therapy through increased cell energy and fluctuation of the cell membrane potential. Using a broad-spectrum frequency, tissue structures can oscillate, and tissue metabolism and cellular processes can be normalized. The stimulation of cells and induction of a resonance effect that makes vibration or an oscillation in the tissues and cells, help to relieve pain, enhance metabolism and distribute the pain mediators and help for resolution of inflammation. Removal of waste substances and increase of nutrients, normalizes the cell metabolism and promotes nerve regeneration (Ogrodzka-Ciechanowicz et al., 2020). High-tone external muscle stimulation (HTEMS) or high-tone therapy is a new alternative approach to electrotherapy techniques, that are used in the management of pain.

In contrast to conventional electrical stimulation, where the frequency remains fixed, and the amplitude is only modulated, in high-tone therapy, the frequency and



Fig. 20.8: Shows application of hi-tone therapy to a patient of bilateral OA knee (the four channels have been used simultaneously).

amplitude are simultaneously modulated and a scanned frequency is applied. HTEMS delivers up to 5,000 mW energy with frequencies between 4,096 Hz and 32,768 Hz into the body (Journal of Modern Rehabilitation, July-2022, Volume-16, November-3). All the frequencies are applied one after another. The higher frequencies produce more energy in the tissues.

The time duration of high tone therapy can be up to 60 minutes, and more than 1 channel can be used simultaneously (**Fig. 20.8**).

There are two current types of High-tone external muscle stimulation (HTEMS), such as:

- ❖ HTEMS without muscle and nerve stimulation.
- ❖ HTEMS with muscle and nerve stimulation.

In both the methods hi-tone therapy affects the metabolic processes of the tissues. The frequency scan oscillates tissue structures and move waste products away from the area of concentration, helping to reduce pain and inflammation. HTEMS with muscle and nerve stimulation, besides the metabolic effects stimulate muscles and peripheral nerves, the effect of which is different than conventional ES methods.

Though different studies done to find the effect of hi-tone therapy on neuro-musculoskeletal conditions gives variable outcomes, this modality is employed for the treatment of the followings:

- ❖ **Nerve compression syndromes (e.g., carpal tunnel syndrome):** Nawal Abou Shady et al., (Turkish Journal of Physiotherapy and Rehabilitation)—September 2021, had a randomized control trial to find the effect of Hi-Tone therapy on improving functional outcome and alleviating pain in patients with carpal tunnel syndrome (CTS). The results of the study concluded that treatment through high tone power therapy is effective on improving function and alleviating pain in patients with CTS than selected physical therapy program only.
- ❖ **Knee osteoarthritis:** Research to find the efficacy of hi-tone therapy on knee osteoarthritis reveal, the modality is beneficial in the management of knee osteoarthritis, when combined with conventional exercises.
- ❖ **Low back pain:** As per a study report, published, in the journal of medical rehabilitation-2017, high-tone power therapy is found beneficial in reducing pain in patients with chronic low back pain.
- ❖ **Cervical pain:** Aleksandra Kulis et al., June 2017 made a study to analyze therapeutic effects of massage using the high-tone power therapy for pain relief in the cervical spine. They concluded hi-tone therapy improved ROM and pain in patients with cervical spine dysfunction.
- ❖ **Coxarthrosis:** A study done by A Mika et al., 2007, **reveal:** The treatment of coxarthrosis using high-tone power therapy and post isometric relaxation had a beneficial effect on the range of motion in the hip and coxarthrosis-related pain in the study group.
- ❖ **Stroke rehabilitation:** A study done by Zbigniew Śliwiński et al., January 2008, reveal, high-tone power therapy with a frequency corresponding to the acoustic band of electric oscillation between 4,400 Hz to 12,300 Hz helped to improve function in paretic upper limb of stroke patients.
- ❖ **Peripheral vascular disease:** Iwona Nowakowska et al., October 2009,

studied the influence of high tone power therapy on the peripheral microcirculation in the lower limbs, and found the modality is a valuable aid in treating disorders of the peripheral blood circulation.

■ CLASS-IV/HIGH POWER LASER THERAPY

High power laser also called, HILT is a therapeutic technique that utilizes a high-power laser to deliver targeted energy to the affected area. It is known for its deep tissue penetration and the ability to stimulate cellular activity and promote healing. In physiotherapy, HILT is commonly used for pain management, tissue repair, and inflammation reduction.

Class IV hot laser therapy (high intensity laser therapy/high power laser therapy) with power output >500 mW can treat a variety of conditions. It creates heat on the surface of the skin due to higher power density (irradiance).

When the light source is placed against the skin, the photons penetrates several centimeters and gets absorbed by the mitochondria. The energy fuels many positive physiological responses resulting in restoration of normal cell morphology and function but at enhanced rate. This modality, which has been discussed extensively in chapter 17, is very much effective for the management of subacute and chronic musculoskeletal disorders.

The results of 2018 study entitled “Effectiveness of high-intensity laser therapy in the treatment of musculoskeletal disorders. A systematic review and meta-analysis of randomized controlled trials” concluded that HILT treatment for back and neck pain significantly improved pain and disability scores compared with controls. It also commented that additional well-designed studies involving larger samples with long-term follow-up were needed to further assess the efficacy of the modality.

Figure 20.9 shows the high power laser device used in physiotherapy.

Electrotherapy Simplified

Salient Features

- The book covers information on inflammation, repair and role of physical agents, basic electricity and magnetism.
- Different electrotherapy and actinotherapy modalities have been described in details with their production, physiological and therapeutic effects, contraindication, precautions and dangers.
- Chapters have been presented in simple manner with suitable diagrams and photographs which can easily be understood by the students.
- Emphasis has been given on practical application of different electrotherapy and actinotherapy modalities.
- The book contains new chapters such as Clinical Reasoning in Electrotherapy and Recent Advances in Electrotherapy.
- Efforts have been made to provide the readers all the latest information on electrotherapy and actinotherapy.
- Multiple choice questions have been increased to 505 with answer keys.
- Efforts have been made to provide a complete information package on electrotherapy and actinotherapy to the readers.

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