Diathermy, from the Greek meaning “through heating,” is the application of shortwave (about 1.8 to 30 MHz frequency and 3 to 200 m wavelength) or microwave (300 MHz to 300 GHz frequency and 1 mm to 1 m wavelength) electromagnetic energy to produce heat and other physiological changes within tissues. Shortwave radiation is within the radiofrequency range (3 kHz to 300 MHz frequency and 1 m to 100 km wavelength), and radiofrequency is between extremely low frequency (ELF) and microwave radiation (Fig. 14-1). Microwave radiation has a frequency between that of radiofrequency and infrared (IR) radiation. Both shortwave and microwave radiation are nonionizing.

The use of diathermy dates back to 1892, when d’Arsonval used radiofrequency electromagnetic fields with 10 kHz frequency to produce a sensation of warmth without the muscular contractions that occur at lower frequencies. The clinical use of shortwave diathermy (SWD) became popular in the early 20th century, and this intervention was frequently used to treat infections in the United States (US) in the 1930s. However, despite a number of reports indicating that SWD can be effective for a range of problems, by the 1950s, with the advent of antibiotics and with growing concerns about potential hazards to the patient and the operator if the equipment was applied inappropriately, its use declined. Diathermy also lost popularity because, by its nature, the electromagnetic field cannot be readily contained to eliminate interference with other electronic equipment and because most diathermy devices were large, expensive, and cumbersome to use. Nonetheless, in recent years, there has been some resurgence of interest in this technology, with the development of smaller better-shielded devices. Some clinicians in skilled nursing facilities and other practice settings are now using diathermy to produce gentle heat in large areas, and in response to the publication of a number of studies regarding the nonthermal effects of pulsed diathermy, clinicians in specialized wound care practices are applying diathermy to facilitate tissue healing by nonthermal mechanisms. Currently, SWD devices are manufactured and available in the US, whereas microwave diathermy (MWD) devices are not manufactured in the US but can be obtained from abroad.

The radiation used for diathermy falls within the radiofrequency range and could therefore interfere with radiofrequency signals used for communications. To avoid such interference the Federal Communications Commission (FCC) has assigned certain frequencies of shortwave and microwave radiation to medical applications. SWD devices have been allocated the three frequency bands centered on 13.56, 27.12, and 40.68 MHz, with ranges of ±6.78, 160, and 20 kHz, respectively. The 27.12 MHz band is most commonly used for SWD devices because it has the widest bandwidth and is therefore the easiest and least expensive to generate. MWD devices for medical application have been allocated the frequency of 2,450 MHz.
Both SWD and MWD can be delivered in a continuous or pulsed mode and when delivered at a sufficient average intensity, can generate heat in the body.\(^1\) When delivered in a pulsed mode at low average intensities, heat is dissipated before it can accumulate; however, pulsed low-intensity electromagnetic energy in the shortwave or microwave frequency range may produce physiological effects by nonthermal mechanisms. Pulsed SWD, when applied at nonthermal levels, is generally referred to as pulsed shortwave diathermy (PSWD); however, the terms pulsed electromagnetic field (PEMF), pulsed radio-frequency (PRF), or pulsed electromagnetic energy (PEME) have also been used to describe this type of radiation. The term PSWD is used in this text.

**PHYSICAL PROPERTIES OF DIATHERMY**

The key factor that determines whether a diathermy device will increase tissue temperature is the amount of energy absorbed by the tissue. This is determined by the intensity of the electromagnetic field produced by the device and the type of tissue to which the field is applied.

**Clinical Pearl**

Electromagnetic field intensity and tissue type determine how much energy will be absorbed by the tissue and how warm it will become.

A pulsed signal can allow heat to dissipate during the off cycle of the pulse. Previously published literature categorized devices with an average power driving the applicator below 38 W as nonthermal.\(^5\) In clinical practice, however, the strength of the magnetic field reaching the tissue, the type of tissue, and tissue perfusion, rather than the power driving the applicator, determine whether the tissue will be heated. Therefore the clinician should use the patient’s report and information provided by the device’s manufacturer to ascertain whether a particular diathermy application increases tissue temperature.

When applied at sufficient power to increase tissue temperature, diathermy has a number of advantages over other thermal agents. It can heat deeper than superficial agents such as hot packs, and it can heat a larger area than ultrasound.

**Clinical Pearl**

Diathermy heats deeper than hot packs and heats a larger area than ultrasound.

SWD is not reflected by bones and therefore does not concentrate at the periosteum or pose a risk of periosteal burning, as does ultrasound; however, MWD is reflected at tissue interfaces, including those between air and skin, between skin and subcutaneous fat, and between soft tissue and superficial bones, and therefore does produce more heat in the areas close to these interfaces. The reflection of microwaves can also lead to the formation of standing waves, resulting in hot spots in other areas. Both SWD and MWD treatments generally need little time for application and do not require the clinician to be in direct contact with the patient throughout the treatment period.
Diathermy • CHAPTER 14  387

CHAPTER 14

Conductivity of Different Tissues at 25 MHz

Tissue Conductivity (siemens/meter)

- Muscle 0.7-0.9
- Kidney 0.83
- Liver 0.48-0.54
- Brain 0.46
- Fat 0.04-0.06
- Bone 0.01


FIG 14-2 An inductive coil shortwave diathermy applicator set-up with cables around the patient’s limb. This type of applicator produces a uniform, incident electromagnetic field that induces an electric field and current within the target tissue.

FIG 14-3 Generation of magnetic fields and induction of electric fields by an inductive coil.

TYPES OF DIATHERMY APPLICATORS

There are three different types of diathermy applicators: inductive coils, capacitive plates, and a magnetron. Inductive coils or capacitive plates can be used to apply SWD, whereas a magnetron is used to apply MWD. PSWD devices use inductive coil applicators in a drum form or capacitive plates.

INDUCTIVE COIL

An inductive diathermy applicator is made up of a coil through which an alternating electric current flows (Fig. 14-2). The alternating current in the coil produces a magnetic field perpendicular to the coil, which in turn induces electric eddy currents in the tissues (Fig. 14-3). These induced electric currents cause charged particles in the tissue to oscillate. The friction produced by this oscillation produces an elevation in tissue temperature.

Electric eddy currents
Magnetic field
Cables

FIG 14-3 Generation of magnetic fields and induction of electric fields by an inductive coil.

Heating with an inductive coil diathermy applicator is known as heating by the magnetic field method because the electric current that generates the heat is induced in the tissues by a magnetic field. The amount of heat generated in an area of tissue is affected by the strength of the magnetic field that reaches the tissue and by the strength and density of the induced eddy currents. The strength of the magnetic field is determined by the distance of the tissue from the applicator and decreases in proportion to the square of the distance of the tissue from the applicator, according to the inverse square law, but does not vary with...
tissue type (Fig. 14-4). The strength of the induced eddy currents is determined by the strength of the magnetic field in the area and by the electrical conductivity of the tissue in the area. The electrical conductivity of tissue depends primarily on the tissue type and the frequency of the signal being applied. Metals and tissues with a high water and electrolyte content, such as muscle or synovial fluid, have high electrical conductivity, whereas tissues with a low water content, such as fat, bone, and collagen, have low electrical conductivity (Tables 14-1 and 14-2). Thus inductive coils can heat both deep and superficial tissues, but they produce the most heat in tissues closest to the applicator and in tissues with the highest electrical conductivity.

**Clinical Pearl**

Inductive coil diathermy applicators produce the most heat in tissues that have high electrical conductivity and that are closest to the applicator.

Inductive coil applicators have been produced in two basic forms, cables and drums. The cables are bundles of plastic-coated wires that are applied by wrapping them around the patient’s limb. When an alternating electric current flows through these wires, eddy currents are induced inside the limb. Cable diathermy applicators are not available at this time. A drum applicator is made of a flat spiral coil contained within a plastic housing (Fig. 14-5). Diathermy devices with drum applicators may have one or two drums or a single drum that can be bent to conform to the area being treated (Fig. 14-6). The drum is placed directly over the area being treated, and the flow of alternating electric current in the coil produces a magnetic field, which in turn induces eddy currents within the tissues directly in front of it (Fig. 14-7).

**CAPACITIVE PLATES**

Capacitive plate diathermy applicators are made of metal encased in a plastic housing or transmissive carbon rubber electrodes that are placed between felt pads. A high-frequency alternating electric current flows from one plate to the other through the patient, producing an electric field and a flow of current in the body tissue that is between the plates (Figs. 14-8 and 14-9). Thus the patient
becomes a part of the electrical circuit connecting the two plates. As current flows through the tissue, it causes oscillation of charged particles and thus an increase in tissue temperature.

Heating with capacitive plate diathermy applicators is known as heating by the electric field method because the electric current that generates the heat is produced directly by an electric field. As with the inductive coils, the amount of heat generated in an area of tissue depends on the strength and density of the current, with most heating occurring in tissues with the highest conductivity. Because current will always take the path of least resistance, when a capacitive plate type of applicator is used, the current will generally concentrate in the superficial tissues and will not penetrate as effectively to deeper tissues if there are poorly conductive tissues, such as fat, superficial to them. Thus capacitive plates generally produce most heat in skin and less heat in deeper structures, in contrast to inductive applicators, which heat the deeper structures more effectively because the incident magnetic field can achieve greater penetration to induce the electric field and current within the targeted tissue⁶⁻⁹ (Fig. 14-10).

**FIG 14-8** Capacitive plate shortwave diathermy applicators placed around the target to produce an electric field directly. Courtesy Mettler Electronics Corporation, Anaheim, CA.

**FIG 14-9** Electric field distribution between capacitive shortwave diathermy plates.

**FIG 14-10** Comparison of heat distribution with inductive coil shortwave diathermy applicator, capacitive plate shortwave diathermy applicator, microwave diathermy, and ultrasound.
MAGNETRON (CONDENSER)

A magnetron, which produces a high-frequency alternating current in an antenna, is used to deliver MWD. The alternating current in the antenna produces an electromagnetic field that is directed toward the tissue by a curved reflecting director surrounding the antenna (Fig. 14-11). The presence of a director and the short wavelength of microwave radiation allow this type of diathermy to be focused and applied to small, defined areas. Therefore these devices can be useful during rehabilitation when only small areas of tissue are involved; they are also popular for the medical treatment of malignant tumors by hyperthermia. The magnetrons used clinically are similar to those used in microwave ovens intended for cooking food.

The microwaves produced by a magnetron generate the most heat in tissues with high electrical conductivity; however, this high-frequency, short-wavelength radiation penetrates less deeply than SWD. Microwaves usually generate the most heat in the superficial skin, although some authors have also reported significant temperature increases in muscles and joint cavities in response to microwave application. These differences in reported depth of heating appear to be related to variations in the microwave frequency used, from 915 to 2,450 MHz, and to variability in tissue composition among different areas of the body and among different species. The shallow depth of microwave penetration, the reflection at tissue interfaces, and the potential for standing waves all contribute to an increased risk of uneven heating and burning of the superficial skin or fat with this type of diathermy device.

EFFECTS OF DIATHERMY

THERMAL EFFECTS

If applied at sufficient average intensity, SWD and MWD will produce a sensation of heat and increase tissue temperature. The physiological effects of increasing tissue temperature are described in detail in Chapter 6 and include vasodilation, increased rate of nerve conduction, elevation of pain threshold, alteration of muscle strength, acceleration of enzymatic activity, and increased soft tissue extensibility. All of these effects have been observed in response to the application of diathermy. The mechanisms underlying these physiological effects of increasing tissue temperature are also described in detail in Chapter 6.

The difference between the effects of superficial heating agents and diathermy is that superficial heating agents only increase the temperature of the superficial first few millimeters of tissue, whereas diathermy heats deeper tissues. Therefore the physiological effects of superficial heating agents occur primarily in the superficial tissues, whereas diathermy also produces thermal effects in deeper tissues. For example, superficial heating agents primarily increase cutaneous circulation, whereas SWD and MWD significantly increase circulation in muscles. Although diathermy is primarily used for its deep heating effects, it can also produce some heat in the skin and superficial tissues, particularly when higher frequencies (450 MHz versus 220 or 100 MHz) are used. Even when skin temperature does not increase the body responds to deep heating by diathermy with sweating and vasodilation. It is thought that heat sensors deep in the body signal these physiological responses to heat.

NONTHERMAL EFFECTS

When applied in a pulsed mode with a low duty cycle, the average intensity of energy delivered by a diathermy device is low and no maintained increase in tissue temperature is produced. Any transient heating of tissues that may occur during a brief pulse is quickly dissipated by the blood perfusing the area during the off time between pulses. However, PSWD, when applied at such nonthermal levels, may have certain physiological effects. Although the mechanisms by which PSWD achieves these effects are unknown, it has been proposed that these effects are produced by modification of ion binding and cellular function by the incident electromagnetic fields and the resulting electric currents.
Increased Microvascular Perfusion

The application of PSWD for 40 to 45 minutes at settings which the device manufacturer states does not increase tissue temperature has been found to increase local microvascular perfusion in healthy subjects and around the ulcer site in patients with diabetic ulcers. Increasing microvascular perfusion, and thus local circulation, can increase local tissue oxygenation, nutrient availability, and phagocytosis. It has been proposed that the clinical benefits of PSWD are in part the result of increased microvascular perfusion.

Altered Cell Membrane Function and Cellular Activity

It has been reported that electromagnetic fields can affect ion binding to the cell membrane, and that this can trigger a cascade of biological processes, including growth factor activation in fibroblasts, chondrocytes, and nerve cells; macrophage activation; and changes in myosin phosphorylation. PSWD is also thought to affect the regulation of the cell cycle by altering calcium ion binding, and it has been shown that exposure to electric fields can accelerate cell growth and division when it is too slow and inhibit it when it is too fast. It has been proposed that alteration of cellular activity and stimulation of adenosine triphosphate (ATP) and protein synthesis may also underlie the observed clinical benefits of PSWD.

Clinical Indications for the Use of Diathermy

Thermal-Level Diathermy

The clinical benefits of applying diathermy at a sufficient intensity to increase tissue temperature are the same as those of applying other thermal agents (see Chapter 6). These benefits include pain control, accelerated tissue healing, decreased joint stiffness, and if applied in conjunction with stretching, increased joint range of motion (ROM). Because diathermy can increase the temperature of large areas of deep tissue, its use is indicated when trying to achieve the clinical benefits of heat in deep structures such as the hip joint or diffuse areas of the spine.

The thermal effects of diathermy may be produced by continuous diathermy or pulsed diathermy at sufficient average intensity. Five studies, all performed by the same research group, found that PSWD, with appropriate treatment parameters, produced increases in soft tissue extensibility, as measured by ankle dorsiflexion or hamstring flexibility. The PSWD used in these studies had an average output of 48 W and was found to increase tissue temperature by up to 3.5 °C in 20 minutes. Therefore the clinical outcome was likely a result of thermal rather than nonthermal effects of diathermy. Three of the studies found that PSWD applied in this manner in conjunction with stretching resulted in increased muscle length or ROM, with two of the studies showing greater effect with diathermy than without. However, the impact of this intervention beyond 3 weeks was not evaluated, and one of the studies found no long-term difference in the effectiveness of diathermy followed by stretching as compared to stretching alone.

Nonthermal Pulsed Shortwave Diathermy

The first documented clinical application of diathermy at a nonthermal level in the US was in the 1930s, when Ginsberg used a pulsed form of SWD to fight infection without producing a significant temperature rise in tissue. He reported successfully treating a variety of acute and chronic infections with this type of electromagnetic radiation and stated that this was the most effective treatment he had ever used. However, this was before antibiotics were commonly available or used. In 1965, A.S. Milinowski patented a device designed to deliver electrotherapy without heat generation. He stated that this device produced good clinical results in a range of conditions while eliminating the factors of patient heat tolerance and contraindications when treating with heat. Such nonthermal levels of PSWD have been evaluated and are now used clinically, primarily to control pain and edema and to promote wound, nerve, and fracture healing.

Control of Pain and Edema

A number of studies concerning the effects of PSWD on recovery from soft tissue injury have shown improved edema resolution and reduction of pain in response to the application of this type of electromagnetic energy. Two double-blind studies on the effects of nonthermal PSWD on acute ankle sprains found a significant decrease in edema, pain, or disability in the treated group compared with a placebo-treated group, and a double-blind study assessing the effects of PSWD treatment found that it decreased pain, erythema, and edema after foot surgery. Maximum power and pulse frequency available on the device were used in all of these studies. It should be noted, however, that not all studies on the use of PSWD have shown such improvements. Both Barker et al and McGill found no significant differences in pain, swelling, or gait between patients treated with PSWD and those treated with a placebo after acute ankle injuries.

Pain Control

A number of studies have evaluated the effect of PSWD on pain associated with a variety of conditions. Double-blind studies on the effects of using a home PSWD device placed in a soft cervical collar on patients with persistent neck pain or acute cervical injuries found significantly greater decreases in pain and increases in ROM in patients using this device for 3 weeks than in patients treated with a sham device. The authors of these studies suggested that these effects could be a result of modification of cell membrane function by the electromagnetic field. Studies without double-blind controls have also reported that PSWD can decrease low back and postoperative pain, and a recent double-blind, placebo-controlled study found that pain and disability decreased significantly more in subjects with chronic low back pain who received pulsed electromagnetic therapy than in control participants. However, another randomized controlled trial with 350 participants found that PSWD provided no additional benefit for patients with neck pain when added to advice and exercise.
Soft Tissue Healing
Nonthermal PSWD has been shown to increase the rate of soft tissue healing in both animal and human subjects.62-65 This effect has been found with incisional wounds,62 pressure ulcers,62,63 burn-related injuries,64 and tendon injuries.66 Surgical wound sites in animals demonstrated increased collagen formation, white blood cell infiltration, and phagocytosis after treatment with PSWD and transected tendons showed significantly (69%) increased tensile strength after treatment with PSWD. Researchers proposed that these effects were the result of increased circulation and improved tissue oxygenation. In vitro studies have also shown increased fibroblast and chondrocyte proliferation in response to PSWD application.66 These effects are likely a result of direct effects of PSWD on cell or cell membrane function.

Nerve Healing
Acceleration of peripheral nerve regeneration in rats and cats, and of spinal cord regeneration in cats, in response to the application of PSWD have been reported67-71; however, the authors of this book are not aware of any published clinical studies regarding the effect of PSWD on the recovery or regeneration of human nerves at this time.

Bone Healing
Animal studies have shown acceleration of bone healing after application of PSWD. A study in 1971 reported acceleration of osteogenesis by PSWD after tooth extraction wounds in dogs,72 and a recent study found that PSWD accelerated the healing of the rabbit fibula after osteotomy.73 The authors of this book are not aware of any published clinical studies regarding the effect of PSWD on human bone healing at this time.

Osteoarthritis Symptoms
Several studies have evaluated the effectiveness of PSWD for improving symptoms of osteoarthritis.74-78 These studies have examined the effects of this intervention on inflammation, ROM, pain, stiffness, functional ability, mobility, and synovial thickness. Two studies did not find any benefits to applying PSWD to patients with osteoarthritis of the knee.74,75 Another study found that PSWD was only effective at reducing stiffness in patients with osteoarthritis of the knee who were less than 65 years old.76 However, one study did find that pain was decreased after the application of PSWD to patients with knee or cervical spine osteoarthritis,77 and another study found that, in patients with knee synovitis and osteoarthritis, synovial thickness and knee pain decreased after the application of PSWD.77 Overall, it appears that PSWD may provide some benefit to patients with osteoarthritis of the knee.

Other Applications
It has been suggested that nonthermal PSWD may also have therapeutic benefits when applied in the treatment of various forms of neuropathy, ischemic skin flaps, cerebral diseases, and myocardial diseases.78 There is also one report on the use of PSWD in the management of head injuries.79

CONTRAINDICATIONS AND PRECAUTIONS FOR THE USE OF DIATHERMY

Although diathermy is a safe treatment modality when applied appropriately, to avoid adverse effects, it should not be used when contraindicated, and appropriate precautions should be taken when necessary.80,81 When applying any form of diathermy at an intensity that may increase tissue temperature, all the contraindications and precautions that apply to the use of thermotherapy apply (see Chapter 6). In addition, there are a number of other contraindications and precautions that apply uniquely to this type of physical agent and some unique reasons for these restrictions. These are described in detail in the related boxes that follow.

CONTRAINDICATIONS FOR THE USE OF ALL FORMS OF DIATHERMY

CONTRAINDICATIONS for the Use of Diathermy
- Implanted or transcutaneous neural stimulators, including cardiac pacemakers
- Pregnancy

Diathermy of any sort should NEVER be used in patients with implanted or transcutaneous stimulators because the electromagnetic energy of the diathermy may interfere with the functioning of the device. Two cases of coma and death have been reported when diathermy has been applied to patients with implanted deep brain stimulators. Also, burns can occur if diathermy is applied to patients with implanted or external electrical stimulation wires or metal containing electrodes.

Diathermy should not be used on patients with pacemakers because these devices have metal components that can become overheated in response to the application of diathermy and because the electromagnetic fields produced by diathermy devices may interfere directly with the performance of pacemakers, particularly those of the demand type. Although the risk of adverse effects is greatest if the thorax is being treated, it is generally recommended that diathermy not be used to treat any area of the body if a patient has a pacemaker, although some authors state that the extremities may be treated in patients with pacemakers.52

Pregnancy
The application of diathermy during pregnancy is contraindicated because of concerns regarding the effects of deep heat and electromagnetic fields on fetal development. Maternal hyperthermia has been shown to increase the risk of abnormal fetal development, and SWD has been shown to be linked to increased rates of spontaneous abortion and abnormal fetal development in animals.84-87 Diathermy exposure, particularly of the lower abdominal and pelvic regions, should be avoided during pregnancy, and because the distribution of an electromagnetic field
CONTRAINDICATIONS FOR THE USE OF THERMAL-LEVEL DIATHERMY

**CONTRAINDICATIONS**

**for the Use of Thermal-Level Diathermy**

- Metal implants
- Malignancy
- Eyes
- Testes
- Growing epiphyses

**Metal Implants**

Metal is highly conductive electrically and therefore can become very hot with the application of diathermy, leading to potentially hazardous temperature increases in adjacent tissues. The risk of extreme temperature increases is greatest when there is metal in the superficial tissues, as can occur with pieces of shrapnel; however, it is recommended that diathermy not be used in any areas containing or close to metal. This contraindication applies to metal both inside and outside the patient. Therefore all jewelry should be removed before diathermy is applied, and care should be taken that there is no metal in the furniture or other objects close to the patient being treated.

**Malignancy**

The use of diathermy in an area of malignancy is contraindicated unless the treatment is for the tumor itself. Diathermy is occasionally used by physicians to treat tumors by hyperthermia; however, such treatment requires fine control of tissue temperature and is outside the realm of the rehabilitation professional. Fine temperature control is required because certain cancer cells have been shown to die at temperatures of 42°C to 43°C but to proliferate at temperatures of 40°C to 41°C.\(^{83}\)

**Over the Eyes**

The eyes should not be treated with diathermy because increasing the temperature of intraocular fluid may damage the internal structures of the eyes.

**Over the Testes**

It is recommended that diathermy not be applied over the testes because of the risk of adversely affecting fertility by increasing local tissue temperature.

**Over Growing Epiphyses**

The effects of diathermy on growing epiphyses is unknown; however, its use is not recommended in these areas because of the concern that diathermy may alter the rate of epiphyseal closure.

CONTRAINDICATIONS FOR THE USE OF NONTHERMAL PULSED SHORTWAVE DIATHERMY

**CONTRAINDICATIONS**

**for the Use of Nonthermal Pulsed Shortwave Diathermy**

- Deep tissues such as internal organs
- Substitute for conventional therapy for edema and pain
- Pacemakers, electronic devices, or metal implants (warning)

**Deep Tissues Such as Internal Organs**

Although contraindicated for the treatment of internal organs, nonthermal PSWD can be used to treat soft tissue overlying an organ.

**Assess**

- Check the patient’s chart for any record of organ disease.
- Check with the patient’s physician before applying PSWD in an area with organ disease present.

**Substitute for Conventional Therapy for Edema and Pain**

PSWD should not be used as a substitute for conventional therapy for edema and pain. It is intended to be used as an adjunctive modality in conjunction with conventional methods, including compression, immobilization, and medications.

**Pacemakers, Electronic Devices, or Metal Implants**

The electromagnetic radiation of PSWD may interfere with the functioning of a cardiac pacemaker and thus may adversely affect patients with cardiac pacemakers. The electromagnetic field emitted by nonthermal PSWD devices can also interfere with other electromedical and electronic devices. Therefore PSWD should not be used over or near medical electronic devices, including pacemakers, and should be used with caution with and around patients with other external or implanted medical electronic devices.

Nonthermal PSWD devices can be used to treat soft tissue adjacent to most metal implants without significantly heating the metal; however, when the metal forms closed loops, as occurs with the wires used for fixating rods and plates in surgical fracture repairs, heating may occur because current can flow in the wire loops. Therefore if a patient has a metal implant, the clinician should determine the type of implant before applying PSWD.

**Ask the Patient**

- Do you have a pacemaker or any other metal in your body?
Assess
- Check the patient’s chart for any information regarding a pacemaker or other metal implants.

If the patient has a pacemaker or is using other medical electronic devices, PSWD should not be used except in extreme circumstances, such as when trying to save a limb from amputation. When considering the use of PSWD in such circumstances, the patient’s physician should be consulted, and the clinician should try to shield all medical electronic devices from the electromagnetic field. In the presence of metal implants, an x-ray should be requested and treatment with PSWD should not be done if the metal forms loops. If the patient has nonlooping metal implants, PSWD may be applied with caution.

PRECAUTIONS FOR THE USE OF ALL FORMS OF DIATHERMY

Near Electronic or Magnetic Equipment
A number of studies and reports have demonstrated the presence of unwanted electrical and magnetic radiation around diathermy applicators. Because the treatment field may interfere with any electronic or magnetic equipment, such as computers or computer-controlled medical devices, it is recommended that the leads and applicators of diathermy devices be at least 3 m and preferably 5 m from other electrical equipment. Precise guidelines are not available because interference depends on the exact arrangement and the shielding of both the diathermy device and the other equipment being used. If interference occurs, then the two types of equipment should be used at different times.

Obesity
Diathermy should be used with caution in obese patients because it may heat fat excessively. Capacitive plate applicators, which generally result in greater increases in the temperature of fat than other types of applicators, should not be used with obese patients.

Copper-Bearing Intrauterine Contraceptive Devices
Although copper-bearing intrauterine contraceptive devices do contain a small amount of metal, calculations and in vivo measurements have shown that these devices and the surrounding tissue increase only slightly in temperature when exposed to therapeutic levels of diathermy. Therefore diathermy may be used by therapists and by patients with such devices.

PRECAUTIONS FOR THE USE OF NONTHERMAL PULSED SHORTWAVE DIATHERMY

PRECAUTIONS for the Use of Nonthermal Pulsed Shortwave Diathermy
- Pregnancy
- Skeletal immaturity

The use of thermal-level diathermy is contraindicated during pregnancy. In addition, because the effects of electromagnetic energy on fetal or child development are not known, nonthermal PSWD should also be used with caution during pregnancy and in skeletally immature patients.

PRECAUTIONS FOR THE USE OF THE THERAPIST APPLYING DIATHERMY

There is concern regarding potential hazards to therapists applying diathermy because of their greater exposure as a result of treating multiple patients throughout the day. These devices produce diffuse radiation and can thus irradiate the therapist if she or he is standing close to the machine. It is therefore recommended that therapists stay at least 1 to 2 m away from all continuous diathermy applicators, at least 30 to 50 cm away from all PSWD applicators, and out of the direct beam of any MWD device during patient treatment.

Some reports have noted above-average rates of spontaneous abortion and abnormal fetal development in therapists after the use of SWD equipment; however, other studies have failed to demonstrate a statistically significant correlation between SWD exposure and either congenital malformation or spontaneous abortion. One comparison of SWD and MWD exposure of therapists found that only MWD increased the risk of miscarriage. However, a recent study found that shortwaves have potentially harmful effects on pregnancy outcome and are specifically associated with low birth weight. This effect increased in a dose-related manner. On balance, given the current research findings, it is recommended that therapists avoid SWD and MWD exposure during pregnancy.

Malignancy and Electromagnetic Fields
Substantial controversy exists regarding the effects of electromagnetic fields on malignancy. The literature on this topic is primarily concerned with the risks associated with living near and working with power lines. Although some reports suggest that the electromagnetic fields generated from power lines may be linked to childhood cancers and leukemia, others have failed to show such an association. In 1995, the Council of the American Physical Society (APS) determined that “The scientific literature and the reports of reviews by other panels show no consistent, significant link between cancer and power line
fields. . . . No plausible biophysical mechanisms for the systematic initiation or promotion of cancer by these power line fields have been identified.” In 2005, they reviewed and again supported this opinion, stating that “Since that time, there have been several large in vivo studies of animal populations subjected for their life span to high magnetic fields and epidemiological studies, done with larger populations and with direct, rather than surrogate, measurements of the magnetic field exposure. These studies have produced no results that change the earlier assessment by APS. In addition, no biophysical mechanisms for the initiation or promotion of cancer by electric or magnetic fields from power lines have been identified.”

The electromagnetic fields associated with power lines are of much lower frequency (50 to 60 Hz) than those used in pulsed or continuous SWD devices (27.12 MHz); thus the application of the data from the studies on power lines to the effects of SWD are limited. At this time, there are no recommendations against using nonthermal levels of PSWD in the area of a malignancy, and there are no indications that PSWD is carcinogenic.

ADVERSE EFFECTS OF DIATHERMY

BURNS
Diathermy can cause soft tissue burns when used at normal or excessive doses, and because the distribution of this type of energy varies significantly with the type of tissue, it can burn some layers of tissue while sparing others.

Fat layers are at the greatest risk of burning, particularly when capacitive plate applicators are used, because they are more effectively heated by this type of device and because fat is less well-vascularized than muscle or skin and therefore is not cooled as effectively by vasodilation. Because water is preferentially heated by all forms of diathermy, the patient’s skin should be kept dry by wrapping with towels to avoid scalding from hot perspiration.

Clinical Pearl
To avoid burns during the application of diathermy the patient’s skin must be kept dry by wrapping with towels.

APPLICATION TECHNIQUES

Thermal-level diathermy is the most effective modality for increasing the temperature of large areas of deep tissue. Therefore treatment with this physical agent is most appropriate when the goal(s) of treatment can be achieved by increasing the temperature of large areas of deep tissue.

Nonthermal PSWD can reduce pain and edema and may accelerate tissue healing. It can be used at the acute, subacute, and chronic stages of an injury; however, the literature and anecdotal reports suggest that better results are achieved when acute conditions are treated. Although not documented in the literature, favorable results have also been reported anecdotally for patients with lymphedema, cerebrovascular accidents, and reflex sympathetic dystrophy (RSD).

APPLICATION TECHNIQUE 14-1

Procedure
1. Evaluate the patient’s problem and determine the goals of treatment.
2. Determine that diathermy is the most appropriate intervention.
   Because diathermy induces an electrical current in the tissues without touching the patient’s body, the use of this physical agent may be particularly appropriate in cases where direct contact with the patient is not possible or desirable—for example, if infection control is an issue, if the patient cannot tolerate direct contact with the skin, or if the area is in a cast. Because heat accumulates with the application of nonthermal PSWD and because little or no sensation is associated with its use, nonthermal PSWD can be used where heat is contraindicated or potentially hazardous and can be applied to insensate patients or to those who cannot tolerate the sensations associated with other physical agents such as cryotherapy or electrical stimulation.
3. Determine that diathermy is not contraindicated.
4. Select the most appropriate diathermy device.
   Choose between a thermal and a nonthermal device according to the desired effects of the treatment and the different types of applicators (inductive coil, capacitive plate, or magnetron) according to the desired depth of penetration and the tissue to be treated.
5. Explain the procedure and the reason for applying diathermy to the patient and the sensations the patient can expect to feel.
   During the application of thermal-level diathermy, the patient should feel a comfortable sensation of mild warmth without any increase in pain or discomfort.
   The application of nonthermal PSWD is not generally associated with any change in patient sensation, although some patients report feeling slight tingling or mild warmth. This sensation may be the result of increased local circulation in response to the treatment.
6. Remove all metal jewelry and clothing from the area to be treated.
   All clothing with metal fastenings or components, such as buttons, zippers, or clips, must be removed from the treatment area. Nonmetal clothing, bandages, or casts do not need to be removed before treatment with diathermy because magnetic fields penetrate these materials unaltered; however, when thermal-level diathermy is used, it is recommended that clothing be removed from the area so that towels can be applied to absorb local sweating.

See later section for more information on selecting a diathermy device.
**APPLICATION TECHNIQUE 14-1**

7. Clean and dry the skin and inspect it if necessary.
8. Position the patient comfortably on a chair or plinth with no metal components. Position the patient so that the area to be treated is readily accessible.
9. If applying thermal-level diathermy, wrap the area to be treated with toweling to absorb local perspiration. If applying nonthermal PSWD, it is not necessary to place towels between the applicator and the body, but a disposable cloth or plastic covering can be used over the applicator when treating conditions in which there is a risk of cross-contamination or infection.
10. Position the device and the applicator(s) for effective and safe treatment application. See later section for more information on positioning.
11. Tune the device.
   SWD devices allow tuning of the applicator to each particular load. Tuning adjusts the precise frequency of the device, within the accepted range, to optimize coupling between the device and the load. Most modern diathermy devices tune automatically. To tune a device that requires manual tuning, first turn it on and allow it to warm up according to the manufacturer’s directions; then turn up the intensity to a low level and adjust the tuning dial until a maximal reading on the power/intensity indicator is obtained.
12. Select the appropriate treatment parameters.
   When applying thermal-level diathermy, the intensity should be adjusted to produce a sensation of mild warmth in the patient. The gauge of heating used in clinical practice is the patient’s reported sensation because calculations of energy delivery and temperature increases are not reliable. The pattern of energy and heat distribution by both SWD and MWD is difficult to predict because it is influenced by the amount of reflection, the electrical properties of different types of tissue in the field, the tissue size and composition, the frequency of the field, and the type, size, geometry, and orientation of the applicator. This issue is further complicated by evidence that the thermal sensation threshold may be affected by the frequency of radiation applied.
   Thermal-level diathermy is generally applied for about 20 minutes.
   
   **Clinical Pearl**
   Thermal-level diathermy is usually applied for 20 minutes.

**POSITIONING**

**Inductive Applicator**

When positioning an inductive applicator with a cable, the cable should be wrapped around the towel-covered limb to be treated, with the turns of the cable spaced at least 3 cm apart. Rubber or wooden spacers should be used to ensure that adjacent turns of the cable do not come into contact with each other.

Alternatively, the cable can be coiled into a flat spiral approximately the size of the area to be treated. Spacers can be used to separate adjacent pieces of cable to ensure that adjacent turns of the cable do not come into contact with each other. The coil should be placed over the area to be treated and separated by six to eight layers of towels (Fig. 14-12).

**Diathermy—cont’d**

When applying nonthermal PSWD, most clinicians select the intensity, pulse frequency, and total treatment time based on the manufacturer’s recommendations and on their individual experience because the clinical research using these devices does not indicate clearly which parameters are most effective. Most manufacturers and studies recommend using the maximum strength and frequency available on the device for all conditions and if the patient reports any discomfort, reducing the pulse rate until the discomfort resolves. Most nonthermal PSWD treatments are administered for 30 to 60 minutes once or twice a day, 5 to 7 times a week.

**Clinical Pearl**

PSWD is usually applied for 30 to 60 minutes, once or twice daily.

Two similar nonthermal PSWD devices manufactured in the US have 6 intensity settings, to provide various field strengths, and 6 pulse frequency settings, to provide between 80 and 600 65 μsec long pulses. Another SWD device (Mettler Electronics, Anaheim, CA) can be used for application of PSWD and allows adjustment of pulse duration, frequency, and field strength (as defined by the maximum power during a pulse).

13. Provide the patient with a bell or other means to call for assistance during treatment and a means to turn off the diathermy device. Instruct the patient to turn off the device immediately if he or she experiences excessive heating or an increase in pain or discomfort.
14. After 5 minutes, check to be certain that the patient is not too hot or is experiencing any increase in symptoms.
15. When the treatment is complete, turn off the device, remove the applicator and towels, and inspect the treatment area. It is normal for the area to appear slightly red, and it may also feel warm to the touch.
16. Assess the outcome of the intervention.
   Reassess the patient, checking particularly for any signs of burning and for progress toward the goals of treatment. Remasure quantifiable subjective complaints and objective impairments and disabilities.

With a drum applicator, the drum should be placed directly over and close to the skin or tissues to be treated, with a slight air gap to allow for heat dissipation. Contact should be avoided when infection control is an issue. The center of the applicator should be placed over the area to be treated. The treatment surface of the applicator should be placed facing and as parallel to the tissues being treated as possible.

The patient should be advised to move as little as possible during the treatment because the strength of the field will change if the distance between the applicator and the treatment area changes, decreasing in proportion to the square of the distance between the treatment surface of the applicator and the tissues being treated (see Fig. 14-4).

For example, if the distance doubles, the strength of the magnetic field will decrease by a factor of four. Thus
maintaining the applicator at a constant distance from the patient is important for consistent treatment.

**Capacitive Applicator**

The two plates of a capacitive applicator should be placed at an equal distance on either side of the area to be treated, approximately 2 to 10 cm (1 to 3 inches) from the skin surface (see Fig. 14-8). Equal placement at a slight distance from the body is recommended for even field distribution in the treatment area because the field is most concentrated near the plates. Unequal placement will result in uneven heating, with the areas closest to the plate becoming hotter than those farther from the plate (Fig. 14-13).

**Magnetron Microwave Applicator**

The magnetron microwave applicator should be placed a few inches from the area to be treated and directed toward the area, with the beam perpendicular to the patient’s skin.

**DOCUMENTATION**

The following should be documented:
- Area of the body treated
- Frequency range
- Average power or power setting
- Pulse rate
- Time of irradiation

---

**TABLE 14-3** Comparison of Different Types of Diathermy Devices

<table>
<thead>
<tr>
<th>Type</th>
<th>Thermal</th>
<th>Microwave</th>
<th>Nonthermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>27.12 MHz*</td>
<td>2450 MHz</td>
<td>27.12 MHz</td>
</tr>
<tr>
<td>Applicator</td>
<td>Inductive coil</td>
<td>Capacitive plate</td>
<td>Magnetron</td>
</tr>
<tr>
<td>Incident field</td>
<td>Electromagnetic</td>
<td>Electric</td>
<td>Electromagnetic</td>
</tr>
<tr>
<td>Tissues most affected</td>
<td>Deep and superficial</td>
<td>Superficial</td>
<td>Small areas</td>
</tr>
</tbody>
</table>

*Shortwave diathermy can also have a frequency of 13.56 or 40.68 MHz; however, the most commonly used frequency is 27.12 MHz.
• Type of applicator
• Treatment duration
• Patient positioning
• Distance of the applicator from the patient
• Patient’s response to the treatment

Documentation is typically written in the SOAP note (Subjective, Objective, Assessment, Plan) format. The following examples summarize only the modality component of treatment and are not intended to represent a comprehensive plan of care.

EXAMPLES

When applying SWD to the low back, document the following:
S: Pt reports low back pain at level 7/10.
O: Pretreatment: Limited lumbar ROM in all planes, limited by pain.
Intervention: 27.12 MHz continuous SWD, power level 3, to low back, drum applicator 5 in from patient, patient prone, 20 min.
A: Pt tolerated SWD well, with dec low back pain.
P: Continue SWD as above before ther ex program.

When applying microwave diathermy to the posterior left (L) knee, document the following:
S: Pt reports stiffness and pain with L knee extension.
O: Pretreatment: L knee extension ROM −40 degrees.
Intervention: 2450 MHz continuous MWD to posterior knee, 3 in from skin surface, power level 4, 15 min. Patient prone with 3 lb cuff weight at ankle.
Posttreatment: Extension ROM increased to −30 degrees.
A: Pt tolerated MWD well, with increased ROM.
P: Continue MWD as above, followed by active ROM exercises into extension.

When applying pulsed SWD to ulcer on the lateral aspect of the right (R) distal leg, document the following:
S: Pt reports he is scheduled to have a cardiac pacemaker implanted in 2 weeks.
O: Pretreatment: R distal LE lateral ulcer 9 × 5 cm.
Intervention: PSWD intensity 6, pulse rate 600 pps, to R distal leg in area of venous insufficiency ulcer, applicator 3 in from lateral leg, 45 min.
Posttreatment: Ulcer dimensions decreased to 7 × 4 cm over last week.
A: Pt tolerated PSWD well, with decreased ulcer size.
P: Continue PSWD as above 1x per day. Discontinue PSWD component of care after pacemaker is implanted.

SELECTING A DIATHERMY DEVICE

When considering purchasing a diathermy device, the first consideration should be whether it outputs a thermal or nonthermal level of energy, or both (Table 14-3). The Food and Drug Administration (FDA) differentiates between diathermy devices according to their thermal or nonthermal mechanism of action. Specifically, the FDA separates diathermy devices into “diathermy for use in applying therapeutic deep heat for selected medical conditions” and “diathermy intended for the treatment of medical conditions by means other than the generation of deep heat.”

When purchasing a device intended for thermal treatments, one should consider the type of applicator (plates, coils, or drum), the frequency band of the energy (short-wave or microwave), and whether the device is self-tuning. In general, drums are the easiest to apply, although coils may provide deeper penetration when applied to the limbs. SWD is generally preferred over MWD because it has a more predictable distribution pattern and self-tuning devices provide greater ease of use.

The nonthermal PSWD devices currently manufactured in the US are similar. They have peak powers between 150 and 400 W, allow adjustment of pulse frequency between 10 and 800 pps and adjustment of pulse duration between 65 μs and 2 ms. Depending on the combination of peak power, pulse frequency, and pulse duration selected, these devices may deliver thermal or nonthermal treatment. If the average power (peak power × pulse duration × pulse frequency) is set to be less than 38 W, then the treatment will be nonthermal.

The following case studies summarize the concepts of diathermy discussed in this chapter. Based on the scenario presented, an evaluation of the clinical findings and goals of treatment are proposed. These are followed by a discussion of the factors to be considered in the selection of diathermy as the indicated intervention, the ideal diathermy device, and the parameters to promote progress toward the goals.

CASE STUDY 14-1

Adhesive Capsulitis

Examination

History

SJ is a 45-year-old physical therapist. She has been diagnosed with adhesive capsulitis of the right shoulder and has been referred to physical therapy. She reports shoulder stiffness, with a tight sensation at the end of range. Although she is able to perform most of her work functions, she has difficulty reaching overhead, which interferes with placing objects on high shelves and with serving when playing tennis, and she has difficulty reaching behind her to fasten clothing.

Tests and Measures

The objective examination reveals restricted right shoulder active ROM (AROM) and passive ROM (PROM) and restricted passive glenohumeral joint inferior and posterior gliding. All other tests, including cervical and elbow ROM and upper extremity strength and sensation, are within normal limits.
Shoulder ROM

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>AROM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>120°</td>
<td>170°</td>
</tr>
<tr>
<td>Abduction</td>
<td>100°</td>
<td>170°</td>
</tr>
<tr>
<td>Hand behind back</td>
<td>R 5 inches below L</td>
<td>—</td>
</tr>
<tr>
<td>PROM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>130°</td>
<td>175°</td>
</tr>
<tr>
<td>Abduction</td>
<td>110°</td>
<td>175°</td>
</tr>
<tr>
<td>Internal rotation</td>
<td>50°</td>
<td>80°</td>
</tr>
<tr>
<td>External rotation</td>
<td>10°</td>
<td>80°</td>
</tr>
</tbody>
</table>

What are some reasonable goals of treatment for this patient? What type of diathermy would be most appropriate? How would you position the patient during treatment? What should be done in addition to diathermy?

Evaluation, Diagnosis, Prognosis, and Goals

<table>
<thead>
<tr>
<th>ICF Level</th>
<th>Current Status</th>
<th>Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body structure and function</td>
<td>Restricted right shoulder ROM</td>
<td>Increase right shoulder passive and active ROM</td>
</tr>
<tr>
<td></td>
<td>Restricted right glenohumeral passive intraarticular gliding</td>
<td>Improve patient’s ability to place objects on overhead shelves, get dressed without assistance</td>
</tr>
<tr>
<td>Activity</td>
<td>Difficulty reaching and lifting over her head</td>
<td>Return patient to playing tennis</td>
</tr>
<tr>
<td></td>
<td>and behind her back</td>
<td>Dresses with ease</td>
</tr>
<tr>
<td>Participation</td>
<td>Decreased tennis playing</td>
<td></td>
</tr>
</tbody>
</table>

Diagnosis

Preferred Practice Pattern 4D: Impaired joint mobility, motor function, muscle performance, and ROM associated with connective tissue dysfunction.

Prognosis/Plan of Care

The goals of treatment at this time are to regain full AROM and PROM of the right shoulder and to return to full sports participation and daily living activities. The loss of active and passive joint motion associated with adhesive capsulitis is thought to be a result of adhesion and loss of length of the anterior inferior joint capsule. Effective treatment should attempt to increase the length of the joint capsule. Increasing tissue temperature before stretching will increase the extensibility of soft tissue, allowing the greatest increase in soft tissue length with the least force while minimizing the risk of tissue damage. Diathermy is the optimal modality for heating the shoulder capsule because this thermal agent can reach large areas of deep tissue. A superficial heating agent, such as a hot pack, would not be as effective because it does not increase the temperature of tissue at the depth of the joint capsule, and ultrasound would not generally be as effective because its heating is limited by the effective radiating area of the sound head.

Intervention

A continuous diathermy device must be used to increase tissue temperature. An SWD device with an inductive coil applicator in a drum form is recommended because this mode of application provides deep, even heat distribution and is easy to apply. The device should be applied to the right shoulder, ideally with the shoulder positioned at end of range flexion and abduction to apply a gentle stretch to the anterior inferior capsule. The diathermy device should be set to produce a sensation of mild, comfortable warmth, and the treatment should be applied for approximately 20 minutes. This diathermy treatment should be followed immediately by a low-load, prolonged stretch to maximize ROM gains.

Documentation

S: Patient reports R shoulder stiffness and a diagnosis of adhesive capsulitis.
O: Pretreatment: R shoulder decreased AROM and PROM when compared with L for flexion, abduction, internal rotation, external rotation (see above for measurements).

Intervention: 27.12 MHz continuous SWD, power level 3, to R shoulder, drum applicator 3 in from patient, patient sitting with R shoulder at end of range flexion and abduction × 20 min followed by 10 min low-load prolonged stretch.

Posttreatment: R shoulder flexion PROM increased from 120 to 140 degrees, abduction increased from 100 to 120 degrees.

A: Pt tolerated SWD well, noting a sensation of warmth, increased PROM after treatment.
P: Continue SWD 3 times weekly as above until patient regains full PROM and returns to prior level of function.

CASE STUDY 14-2

Acute Ankle Inversion Sprain

Examination

History

MB is a 24-year-old woman recreational soccer player who sustained a grade II left ankle inversion sprain approximately 48 hours ago. She has been applying ice and a compression bandage to the ankle, resting and elevating the ankle as much as possible, and using a cane to reduce weight bearing when walking. She has been referred to physical therapy to attain a pain-free return to sports as rapidly as possible. She reports moderate pain at the lateral ankle that is aggravated by weight bearing and ankle swelling that is aggravated when her ankle is in a dependent position.
Tests and Measures
The objective examination reveals a mild increase in superficial skin temperature at the left lateral ankle and edema of the left ankle, with a girth of 25.5 cm (10 inches) on the left compared with 21.5 cm (8.5 inches) on the right. Left ankle ROM is restricted in all planes, with 0 degrees dorsiflexion on the left and 10 degrees on the right, 20 degrees plantar flexion on the left and 45 degrees on the right, 10 degrees inversion on the left, with pain at the lateral ankle at the end of range, and 30 degrees on the right, and 20 degrees eversion on the left. Isometric testing of muscle strength against manual resistance at midrange revealed no abnormalities.

What are the goals of treatment at this time? What type of diathermy is appropriate? What type of diathermy is contraindicated for this patient? How would you position this patient during treatment? What else should this patient do?

Evaluation, Diagnosis, Prognosis, and Goals

<table>
<thead>
<tr>
<th>ICF Level</th>
<th>Current Status</th>
<th>Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body structure and function</td>
<td>Left ankle pain, swelling, increased temperature, decreased ROM</td>
<td>Decrease symptoms and regain normal ROM</td>
</tr>
<tr>
<td>Activity</td>
<td>Decreased weight-bearing tolerance, limited ambulation</td>
<td>Return to normal ambulation and weight-bearing</td>
</tr>
<tr>
<td>Participation</td>
<td>Unable to play soccer</td>
<td>Return to playing soccer in 4 weeks</td>
</tr>
</tbody>
</table>

Diagnosis
Preferred Practice Pattern 4D: Impaired joint mobility, motor function, muscle performance, and ROM associated with connective tissue dysfunction.

Prognosis/Plan of Care
The goals of treatment at this time are to control pain, resolve edema, and restore normal ROM for the patient to return to full sports participation. The diagnosis of a grade II ankle sprain indicates that there has been some damage to the ankle ligaments; therefore the goals of treatment should also include healing of these soft tissues.

Nonthermal PSWD is an indicated adjunctive treatment for pain and edema and has also been shown to accelerate soft tissue healing. Because this patient is already applying rest, ice, compression, and elevation (RICE) to her ankle at home and desires a rapid return to full sports participation, the addition of PSWD treatment may help maximize her rate of recovery. Thermal-level diathermy should not be applied to this patient because the use of all thermal agents is contraindicated in the presence of acute injury or inflammation.

Intervention
It is proposed that treatment with nonthermal PSWD be started immediately after the evaluation to reduce pain and swelling. The patient's limb should be placed in a comfortable elevated position to optimize the reduction of swelling. The PSWD applicator should be positioned over the lateral aspect of the ankle, as close to the skin as possible, with the center of the applicator over the area of the ankle presenting with the most marked swelling and as parallel as possible to the damaged tissues.

Daily application of PSWD for 30 minutes, with power and pulse rate settings of 6, is generally used for treatment of this type of acute injury. If the patient complains of any increase in discomfort, the pulse rate should be decreased until the discomfort resolves. The PSWD treatment can be followed by the application of ice, after which the ankle should be wrapped in a compression bandage. The patient should continue with RICE and should be instructed in appropriate ambulation, weight bearing, and ROM exercises. She may also need to wear a splint if the ankle is unstable.

Documentation
B: Patient sustained a grade II L ankle inversion sprain 48 hours ago, has been applying RICE, and reports L ankle pain, swelling, and decreased weight-bearing tolerance.
C: Pretreatment: L ankle girth 25.5 cm, R ankle girth 21.5 cm. L ankle ROM restricted in all planes, with 0 degrees dorsiflexion, 20 degrees plantar flexion, 10 degrees inversion with pain at the lateral ankle at the end of range, and 20 degrees eversion.

Intervention: PSWD to L lateral ankle, 3 in from skin, power and pulse settings of 6, for 30 min. Ice and compression applied after PSWD.

Posttreatment: Mildly improved L ankle ROM, ankle circumference unchanged.
A: Pt experienced no discomfort with treatment.
P: Continue daily PSWD and RICE protocol at all other times. Patient will be instructed in ambulation, weight bearing, and ROM exercises.

CASE STUDY 14-3

Sacral Pressure Ulcer

Examination
History
FG is an 85-year-old man with a stage IV sacral pressure ulcer. He is bedridden, minimally responsive, and dependent for all bed mobility and feeding activities. He is able to swallow but eats poorly. Treatment until this time has consisted of sharp débridement and hydrocolloid dressings. Although this treatment has resulted in a reduction of the yellow slough, there has been little change in wound area over the last month.
Tests and Measures

The pressure ulcer is 15 × 8 cm and 3 cm deep in the deepest area. There is no tunneling or undermining. Approximately 70% of the wound bed is red and granulating, and 30% is covered with yellow slough.

What are reasonable goals of treatment for this patient?
What type of diathermy should be used and why? How often should diathermy be applied? What other aspects of wound care are important for this patient?

Evaluation, Diagnosis, Prognosis, and Goals

<table>
<thead>
<tr>
<th>ICF Level</th>
<th>Current Status</th>
<th>Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body structure and function</td>
<td>Sacral ulcer (impaired tissue integrity), reduced strength</td>
<td>Achieve a completely red wound base (short-term), decrease ulcer size (long-term), wound closure (long-term)</td>
</tr>
<tr>
<td>Activity</td>
<td>Bedridden, poor appetite, at risk for infection</td>
<td>Prevent infection</td>
</tr>
<tr>
<td>Participation</td>
<td>Dependent for bed mobility and eating</td>
<td>Decrease patient’s medical care requirements</td>
</tr>
</tbody>
</table>

Diagnosis

Preferred Practice Pattern 7E: Impaired integumentary integrity associated with skin involvement extending into fascia, muscle, or bone and scar formation.

Prognosis/Plan of Care

Nonthermal PSWD has been shown to accelerate the healing of chronic open wounds, including pressure ulcers. One advantage of this treatment modality over other adjunctive treatments is that it can be applied without removing the dressing, thus limiting the mechanical and temperature disturbance to the wound and reducing the time required to set up the treatment. Also, because nonthermal PSWD produces little sensation, it can be applied even if the patient is insensate or cognitively incapable of giving sensory feedback about the treatment. Limiting the mechanical disruption of the wound is particularly important in this case because 70% of the wound bed is covered with red granulation tissue that is fragile but does have the potential to heal.

Intervention

A comprehensive wound care program that addresses pressure relief, dressings, the nutritional status of the patient, and débridement, when necessary, is required to optimize the healing of this patient’s wound. Nonthermal PSWD may be used as an adjunct to these interventions to facilitate wound healing and closure. The patient should be positioned with the treatment surface of the applicator as close and as parallel to the tissues to be treated as possible, with the center of the applicator over the deepest part of the wound. The wound dressing may be left in place. If tunneling were present, the center of the applicator should be positioned over the deepest portion of the tunnel to promote closure of the tunnel before the more superficial wound site closes. The treatment surface of the applicator head can be covered with a plastic bag or surgical covering if infection control is an issue. It is recommended that this wound be treated either twice a day for 30 minutes or once a day for 45 to 60 minutes. If the patient appears to have any discomfort, the pulse rate should be lowered. The pulse rate setting should also be reduced if the surface of the wound appears to be closing before the depth of the wound has completely filled.

Documentation

S: Bedridden, poorly responsive pt with stage IV sacral pressure ulcer.
O: Pretreatment: Sacral ulcer 15 × 8 cm and 3 cm deep in the deepest area. No tunneling or undermining. 70% of the wound bed is red and granulating, and 30% is covered with yellow slough.
Intervention: PSWD twice daily for 30 min to sacral ulcer, power 6 and pulse rate 600pps, pt prone, applicator covered with sheath and 3 in from wound.
Posttreatment: Wound appears unchanged after 2 treatments.
A: PSWD applied with no noticeable adverse effects.
P: Continue PSWD twice daily for 1 more week. Continue if wound improves, discontinue if no benefit appreciated.

CHAPTER REVIEW

1. Diathermy is the application of shortwave or microwave electromagnetic energy to a person’s body.
2. The effects of diathermy may be thermal or nonthermal. Continuous diathermy produces thermal effects and is used for heating large areas of deep tissue. PSWD is generally used to produce nonthermal effects and may provide pain control, edema reduction, decreased symptoms of osteoarthritis, and accelerated wound, nerve, and bone healing.
3. Contraindications for the use of diathermy depend on whether the application is thermal or nonthermal. Diathermy is contraindicated for both thermal and nonthermal applications if a patient has implanted or transcutaneous neural stimulators (including cardiac pacemakers) or is pregnant. Contraindications for thermal-level diathermy include metal implants, malignancy, and application over the eyes, testes, and growing epiphyses. Contraindications for nonthermal diathermy include application to deep tissue such as...
organs, as a substitute for conventional therapy for edema and pain, and the presence of electronic devices, or metal implants.

4. Precautions for all forms of diathermy include electronic or magnetic equipment in the vicinity, obesity, and copper-bearing intrauterine contraceptive devices. Precautions for the use of PSWD include pregnancy and skeletal immaturity.

5. The reader is referred to the Evolve web site for further exercises and links to resources and references.

**ADDITIONAL RESOURCES**

**Web Sites**
Accelerated Care Plus: Manufacturer of a thermal and nonthermal SWD unit. The web site has information on that unit and has useful links to professional organizations and medical databases. www.acplus.com
Mettler Electronics: This company produces thermal and nonthermal SWD units, and their website includes information and specifications on their products. www.mettlerelectronics.com

**GLOSSARY**

**Continuous shortwave diathermy (SWD):** The clinical application of continuous shortwave electromagnetic radiation to increase tissue temperature.

**Diathermy:** The application of shortwave or microwave electromagnetic energy to increase tissue temperature, particularly in deep tissues.

**Duty cycle:** The proportion of time energy is being delivered.

Duty cycle = on time/[on time + off time]

**Inductive coil applicator:** A coil through which an alternating electric current flows producing a magnetic field perpendicular to the coil and, in turn, inducing electric eddy currents in the tissue within or in front of the coil. This type of applicator can be used to apply shortwave diathermy.

**Low-frequency electromagnetic radiation:** Electromagnetic radiation that is nonionizing and that cannot break molecular bonds or produce ions. This includes extremely low frequency waves, shortwaves, microwaves, infrared, visible light, and ultraviolet.

**Magnetron:** An applicator that produces a high-frequency alternating current in an antenna. This type of applicator is used to apply microwave diathermy.

**Microwave radiation:** Nonionizing electromagnetic radiation with a frequency range 300 MHz to 300 GHz, which lies between the ranges of radiofrequency and IR radiation.

**Pulsed shortwave diathermy (PSWD):** The clinical application of pulsed shortwave electromagnetic radiation in which heating is not the therapeutic mechanism of action.

**Shortwave radiation:** Nonionizing electromagnetic radiation with a frequency range of approximately 3 to 30 MHz. Shortwave is a band within the radiofrequency range. The radiofrequency range lies between ELF and microwave radiation.

**REFERENCES**

69. Wilson DH, Jagadeesh P: Experimental regeneration in peripheral nerves and the spinal cord in laboratory animals exposed to a pulsed electromagnetic field, Paraplegia 14:12-20, 1976.


82. Health Notice (Hazard) 80(10): Implantable cardiac pacemakers: interference generated by diathermy equipment, Washington, DC, 1980, DHHS.


108. sofPulse: Electropharmacology, Inc, Pompano Beach, FL.