Slide 1

Electrotherapy Made Simple
How to Perform Safe and Effective Electrotherapy Treatments

Slide 2

NMES
• Neuromuscular Electrical Stimulation
• Stimulation through intact peripheral motor nerves
• Treatment goals:
  -- Strengthening
  -- Recovery motor control

Slide 3

EMS, Electrical Muscle Stimulation
• Direct stimulation of membrane of denervated muscle
• Wide pulse duration, high intensity
• Treatment goals:
  -- Retard muscle atrophy
  -- Improve local blood flow
Slide 4

FES • FES (Functional Electrical Stimulation)  
- NMES to promote function  
- Stimulation is often delivered in a 'timed' manner  
- Often difficult to achieve well coordinated movement  
- Common applications: Hemiparetic shld, drop foot, wrist drop

Slide 5

TENS  
• Transcutaneous Electrical Nerve Stimulation  
• Externally applied  
• Portable  
• For pain management  
• "Electric Tylenol™"

Slide 6

Why Use Electrotherapy?  

Studies show that 85 to 90 percent of electrotherapy treatments are for:  

PAIN
Why Use Electrotherapy?

- Muscle Re-education/Strengthening
- Increase in Circulation
- Decrease Spasm
- Decrease Edema
- Decrease Inflammation
- Increase Range of Motion

---

Six Simple Rules of Electrotherapy
Parameter Adjustment and Electrodes

- Amplitude
- Constant Current/Constant Voltage
- Frequency
- Duty Cycle/Cycle Time
- Phase Duration
- Electrode Placement

---

Parameter selection: key to producing desired physiologic responses

- Target Tissue
  - Sensory, motor, or pain nerve fibers
- The current flows through the target tissue to the other electrode and up the other lead wire to the stimulator

---
Three Levels of Stimulation

- Sub-Sensory
- Sensory
- Motor
- Noxious

Current Amplitude

- Increasing the amplitude (current flow) will:
  - Increase the depth of penetration
  - Increase the number of neurons depolarized both superficially and deeper
  - Amplitude should be adjusted to produce a desired physiologic response
  - Physiologic response is the key, do not focus on the number of milliamps

How Much is Enough? “Hot Sauce”

Amplitude increases are determined by patient response.

- First; “Tell me when you feel it.” (Sensory)
- Second; you see a muscle twitch or contraction. (Motor)
- Third; “Tell me when it becomes uncomfortable.” (Noxious)
You must know what you want to accomplish!!!
Ohm’s Law
(Problem)

• Current flow (intensity/amplitude) changes with changing resistance
• Ohm’s law (I=V/R) governs relationship between intensity and resistance
• Clinical implications
  – Skin irritations
  – Burns

Constant Current vs. Constant Voltage

• Constant Current mode (CC)
  – Machine keeps intensity constant by changing voltage to compensate for changing resistance
  – Very constant stimulation
  – Possible discomfort with small electrode
• Constant Voltage mode (CV)
  – Machine keeps voltage constant regardless of changing resistance
  – Intensity level and therapeutic effect will fluctuate
  – Ideal for dynamic, high intensity applications since risk of discomfort is low

Frequency

• Measured in Hertz
• Pulses per second (Low Frequency Monophasic or Biphasic, pps)
• Beats or Cycles per Second (Middle Frequency or Alternating Current, bps)
Slide 16

Pulsed Current

Monophasic

Biphasic

0

0

0

Slide 17

Alternating Current

• Continuous bidirectional flow of current
• Note that there is no break between each cycle

Slide 18

Alternating Current: Cycle Characteristics

Phase

300 µsec

300 µsec

Amplitude

Cycle duration

Phase
Slide 19

Direct Current

Slide 20

How Do You Determine Frequency?

It is determined by what you are treating and what you want to accomplish.

- Pain (Gate Theory)
  - 80 to 150pps modulated or 100pps fixed
- Pain (Opiate Release)
  - 1 to 10pps modulated or 6pps fixed
- Muscle Strengthening
  - 35 or 50pps fixed

Slide 21

How Do You Determine Frequency?

Cont.

- Spasm
  - Sensory Response or Muscle Pump 100pps
- Increase in Circulation
  - 100pps
- Decrease Edema (ion movement)
  - 100pps
- Decrease Edema (muscle pump continuous)
  - 5pps
Slide 22

How Do You Determine Frequency? Cont.

- Decrease Edema (muscle pump cycled) – 35pps
- Increase in Range of Motion – Cycled 35pps
- Decrease in inflammation – 100pps

Slide 23

Duty Cycle/Cycle Time

AKA On/Off Time
Continuous: Typically used to treat pain, edema (ion movement), and to increase circulation
Cycled: Typically used in muscle strengthening and re-education, edema (muscle pump)

Slide 24

Duty Cycle/Cycle Time

- When setting cycle times for post surgical or stroke re-education in early stages the on/off times should be long to allow for the patient to perform a contraction or task (ex. 10/50 or 10/30).
- As the patient gains the ability to sustain a contraction in the allotted off time shorter on/off times should be utilized (4/12 progressing to 5/5).
Phase Duration

- Also referred to as pulse width
- Measured in microseconds (usec)
- Longer phase durations increase the depth of penetration
- Longer phase durations recruit more motor units
- Longer phase durations elicit stronger muscle contractions

Strength Duration Curve: the basis for selection amplitude and “width”

Pulsed Current

Monophasic

Biphasic
Slide 28

**Alternating Current: Cycle Characteristics**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Amplitude</th>
<th>Cycle Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>300 µsec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>300 µsec</td>
<td></td>
</tr>
</tbody>
</table>

---

Slide 29

**Determining Phase Duration**

- **Treatment of Pain Syndromes**
  - Phase duration should be 200 usec or less

- **Muscle Strengthening/Re-education**
  - Phase durations should be 200 usec or greater; this allows for a stronger contraction with less amplitude

---

Slide 30

**Electrodes**

- Issues concerning electrodes is the most common cause for complaint by the clinician and the patient. In order to reduce problems with electrodes you should ask yourself the following questions:
  - What size electrode is the best to use?
  - How should the skin be prepped?
  - How many times can an electrode be used?
  - How is electrode placement determined?
Electrode Issues

- Should...
  - Have low impedance
  - Conduct current uniformly
  - Maintain uniform contact
  - Allow movement
  - Avoid skin irritation

Electrode Skin Interface

- The skin is a resistor to the flow of current
  - Good skin preparation is important; always clean skin to remove dirt, oils, and dead skin
  - To lower impedance clean the skin with warm water (Do Not use alcohol or soap)
  - Proper electrodes and conductive medium are essential

Electrode Placement

- Provided you have a knowledge of anatomy there are three rules for placement. For pain:
  - Above and below the area
  - Surrounding the area
  - Directly on the area

- For muscle strengthening:
  - One on the motor point at the muscle origin
  - The second on the motor point near the musculotendinous junction
Electrode Spacing Issues

- Electrodes should be placed so the flow of current can reach the target tissue
- The farther apart the deeper the penetration
- Placed too close the potential exists for greater concentration
- Superficially this can result in discomfort

Electrode Issues: choosing appropriate electrode size

- Small electrode (ex: 2 x 2 inches)
  - Increases current density
  - Recruits fewer motor units
  - More "uncomfortable"
  - Better for targeting small areas
- Large electrode (ex: 4 x 5 inches)
  - Decreases current density
  - Recruits more motor units
  - More comfortable
  - Better for targeting larger areas

Electrode Usage

- Maximum number of uses:
  - 10 for most waveforms
  - 8 for IFC, Premod and Russian
- In order to get maximum usage of the electrodes you should:
  - Place a few drops of water on the electrode and replace on the plastic cardstock
  - Seal in the resealable bags
Clinical Education

Decision Making Tree for Electrotherapy

- Physiological mechanism to activate?
- Target tissue to stimulate?
- Selection of appropriate electrotherapy treatment (parameters best suited to stimulate tissue)
  - Phase Duration
  - Amplitude (intensity)
  - Frequency (pps, Hz)
  - on/off time
  - Treatment Time
  - Number of treatments per day or week
  - Electrode placement

Waveforms: various configurations of the 3 electrotherapy currents

- Interferential
- Premodulated
- Russian
- Biphasic
- “VMS”
- High Volt Pulsed current
- Microcurrent
- Direct current

Clinical Decision Process: choosing a waveform to meet your objective

Concept: “the waveform is not the treatment!”

- We use waveforms to deliver a specific electrotherapy intervention (e.g. sensory level electroanalgesia)
- Always choose treatment first then choose suitable waveform
Interferential Quad-Polar

- Alternating Current
- Amplitude modulated medium-frequency current (2,000-5,000 Hz)
- Uses two channels of differing carrier frequencies to create a "beat" frequency within the tissues.
  - Scan - amplitude modulation
  - Sweep - frequency modulation
  - CC/DV
  - Carrier Frequency

Interferential current

Wave 1 (in red) and Wave 2 (blue)

Beat Pattern (in green)

Interferential current

- Marketing made IFC very popular in Europe since 50’s, in USA since 80’s
- Nemec (1950) claimed that
  - High carrier frequency allows deeper and more comfortable penetration
  - Low modulation frequency produces low frequency effect in targeted tissue
Interferential current

- Application
  - Quadrupolar
- **4 electrodes**
- Treatment field where currents cross

Clinical Benefits

- Comfortable
- Targeting hard to reach tissues (e.g. subscapularis)
- **Indication: Pain modulation**
  - Acute pain
  - Chronic pain

Premodulated Waveform

- “Premodulated”
  - Bipolar application (2 electrodes)
  - “Sine Wave” creation occurs in machine
  - Treatment field larger
  - Preferred method
  - Ease of application
Slide 46

Premodulated Current

Beat Frequency: 100 Hz

Premodulated Current — is simply taking two alternating medium frequency currents mixed within the electronics of the unit and delivered through two electrodes.

Slide 47

Clinical Benefits

- Comfortable
- Simple two electrode setup
- Easily applied to small joints of the upper extremity
- Indication: Pain Modulation
  - Acute Pain
  - Chronic pain
  - Muscle Contraction

Slide 48

Russian current

- Burst-modulated medium frequency current (2,500Hz)
- Popular for muscle strengthening since early 80's
- Yakov Kotz claimed (’77) his current
  - Produced more force than voluntary contraction (30% more than MVC)
  - Was more comfortable
Slide 49

**Russian current**
- Sinusoidal waveform
- Frequency 2,500Hz
- Bursts of 10ms each
- Burst interval 10ms
- Resulting duty cycle 50%

- Burst frequency 50Hz
- On:Off time 10:50 (10 secs on, 50 secs off)

Slide 50

**Russian current**
- Compared to other waveforms
  - Tissue reacts to each burst as if it were a single pulse
  - Muscle strengthening effects not better than pulsed current
  - Stimulation not more comfortable, actually less comfortable at high intensities
- Literature support
  - Muscle strengthening: Yes
  - Pain inhibition: good case report literature

Slide 51

**Biphasic current**
- Pulsed waveform
- Most frequently used waveform
  - When used for pain inhibition: TENS (Transcutaneous Electrical Nerve Stimulation)
  - When used for muscle strengthening: NMES (Neuromuscular Electrical Nerve Stimulation)
  - Versatility depends on pulse characteristics
Slide 52

**Biphasic current**
- Two phases per pulse
- Symmetrical or asymmetrical
- Balanced or unbalanced
- Frequency 0-250Hz
- Can be delivered in bursts
- Different on/off ratios

Slide 53

**Biphasic current ("Excellent Versatility")**
- Compared to other waveforms
  - Suitable for high intensity and/or long term applications
    - Abundance of equipment available
- Literature support
  - Edema management: Yes
  - Stimulation of circulation: Yes
  - Muscle strengthening: Yes
  - Pain control: Yes

Slide 54

**VMS™ “Excellent Versatility”**
- VMS™ a trademarked name of Chattanooga
- Variable Muscle Stimulation
  - Symmetrical Biphasic Square Waveforms with a 100 mSec interphase interval
Slide 55

VMS
- The most comfortable NMES waveform
- Allows for two channels to interact with each other
  - Co-contract
  - Reciprocal
- VMS Burst Mode – proven to be more effective than Russian
  - Bellew et. al.

Slide 56

VMS FR?
- VMS: patented waveform which has utilized by Chattanooga Group for decades
- Pulse is relatively short and therefore good patient tolerance
- The VMS waveform is delivered through 2 channels, typically placed on agonistic and antagonistic muscle groups

Slide 57

Physiological Rationale
- EMG studies have demonstrated that agonist/antagonist muscle pairs co-contract during movements in predictable patterns
- In these contraction patterns agonist and antagonist muscles show alternating bursts of activity to initiate, sustain and finally stop the movement
Slide 58

Inside VMS FR

- Agonist channel initiates movement with a brief burst of power, then decreases
- Antagonistic channel follows with brief burst of full output to slow down the initial acceleration of the agonist, followed by a low output to regulate the movement of the agonist
- The movement is completed by a final burst of output in both channels
- Neither muscle group is ever totally silent during any phase of the movement
- VMS FR waveform mimics this muscle activity to facilitate the return of normal muscle movement in conditions where neuromuscular control is impaired

Slide 59

High Volt

- Monophasic waveform, ‘twin peak’, very short pulse duration, high voltage
- Developed during 40’s (Bell labs)
- High voltage and short pulse result in low impedance
- Claims:
  - Deeper penetration
  - More comfortable
  - More effective

Slide 60

High Voltage Pulsed Current

- High Volt current is a rapid succession of two brief high voltage impulses. The current flows in only one direction, which is determined by the selection of either a “positive” or “negative” polarity setting.
CLINICAL EDUCATION

Slide 61
High Volt
- Monophasic, twin-peak
- Pulsed: 1-200 pps
- Pulse duration: 100μs
- Voltage: 150-500V

Slide 62
High Volt
- Literature support
  - Wound healing: Yes
  - Retardation of edema control: Yes
  - Spasticity control: Yes
  - Muscle strengthening: Weak!!!!
  - Pain control: yes

Slide 63
Microcurrent
- Continuous or pulsed monophasic waveform of very low amplitude (<1mA)
- Becker ('67) proposed model of tissue healing based on studies revealing a 'current of injury'
  - Normal healing tissue, unlike non-healing tissue, contains characteristic electrical current
  - Current is in microampere range
  - Externally applied current may theoretically stimulate healing
Microcurrent

- Monophasic
- Pulsed or continuous
- Intensity <1,000 μA
- Polarity reversal optional

Microcurrent

- Application
  - One electrode on/in lesioned tissue, one electrode close to it
  - Polarity reversal recommended
  - Frequency <1 Hz for wound healing
  - Amplitude is subsensory
- Literature support
  - A scarcity of literature

Direct current

- First accounts of medical use of electrical currents go back hundreds of years
- Unidirectional nature provides electromotive force that can move electrically charged particles
- Primary use is iontophoresis
- Has polarizing effect on tissue... Skin damage may result if not dosed properly
**Slide 67**

**Clinical Education**

**Direct Current**
- Monophasic
- Continuous or pulsed (interrupted)

- Intensity very low
- Cathode: negative
- Anode: positive

---

**Slide 68**

**Clinical Education**

**Direct Current**
- Application
  - Iontophoresis:
    - Active electrode of same polarity as meds
    - Dispersive electrode proximal to it and larger
  - EMS (denervated muscle):
    - Equal size electrodes on either side of muscle belly
- Polarizing effect under electrode
- Literature support
  - Iontophoresis: Yes
  - EMS: Maybe

---

**Slide 69**

**Clinical Education**

**Protocol Development**
Slide 70

**Acute/Chronic Pain**

**Gate Mechanism**

- Phase Duration: 200 usec or lower
- Frequency: 80 – 150 Sweep; 100 Fixed
- Amplitude: Strong Sensory
- Cycle Time: Continuous
- Treatment Time: 20 to 30 minutes

---

Slide 71

**Acute/Chronic Pain**

**Opiate Release Mechanism**

- Phase Duration: 200 usec
- Frequency: 1 – 10 Sweep; 5 Fixed
- Amplitude: Motor
- Cycle Time: Continuous
- Treatment Time: 20 to 60 Minutes

---

Slide 72

**Muscle Strengthening/Re-Education**

- Waveform: Symmetrical Square Biphasic
- Phase Duration: 250usec or greater
- Frequency: 35 or 50
- Amplitude: Strong Motor
- Cycle Time: Early Stage 10/50 progress to 4/12 or 5/5 in latter stages
- Treatment Time: 10-20 minutes; determined by patient fatigue. Longer treatment times are indicated for disuse atrophy
Slide 73

Edema: Muscle Pump Protocol (continuous)
- Phase Duration: 200 usec or greater
- Frequency: 5pps
- Amplitude: Sub-max Motor
- Cycle Time: Continuous
- Treatment Time: 20 minutes

Slide 74

Edema: Muscle Pump Protocol (cycled)
- Phase Duration: 200 usec or greater
- Frequency: 35 pps
- Amplitude: Strong Motor
- Cycle Time: 1:1 or 1:2 ratio
- Treatment Time: 20 minutes

Slide 75

Edema: Polarity Driven
- Waveform: High Volt
- Phase Duration: Preset
- Frequency: 100 pps
- Amplitude: Strong Sensory
- Cycle Time: Continuous
- Polarity: Negative
- Treatment Time: 60 minutes
**Slide 76**

**Electrotherapy Contraindications**
- *Cardiac pacemaker*
- Cardioverter defibrillator
- Over the carotid sinus/anterior transcervical area
- Over heart transthoracic area
- Over the abdominal, lowback and pelvic area during pregnancy
- Areas of venous or arterial thrombosis
- Thrombophlebitis
  *

**Slide 77**

**Contraindications cont..**
- Phrenic nerve or urinary bladder stimulator
- Cancerous lesions
- Neoplasm
- Superficial metal (e.g. staples, pins, external fixators)
- Patients prone to seizures
- Transcerebral stimulation
- Stimulation over the eyes
- Pain of unknown etiology

**Slide 78**

**THANKYOU**
Slide 1

Short Wave Diathermy

Slide 2

Diathermy ????

• Old Modality

• New Era

Slide 3

Introduction

• What is Shortwave Diathermy (SWD)?
  • Clinical application of high frequency electromagnetic energy to the body in the radio frequency of 27.12 MHz (assigned by the FCC) to generate heat in deep tissues.
  • As the electromagnetic energy passes through the soft tissues they create resistance causing these tissues to heat up.
Slide 4

Shortwave Diathermy Defined

- Diathermy is a Greek word which means “through heat”
  - Dia – through
  - Thermy – heat

- Shortwave refers to the shortwave electromagnetic band of the electromagnetic spectrum. It is very high frequency but short in wavelength.

Slide 5

History

- Forms of diathermy have been used since the late 1800’s to treat a wide range of medical diseases and conditions.
- A French physician and physiologist (Jacques-Arsene d’Arsonval) observed that high frequency electromagnetic currents applied over soft tissue produced perceptible warming without muscle contraction, Kloth et al.
- In 1907 a German physician (Carl Franz Nagel Schmidt) coined the term “diathermy”.

Slide 6

History

- Shortwave and Microwave diathermy were created in the mid 1900’s but the use of this modality has been sporadic over the years.
- Three types of devices have been developed over the years:
  - Longwave
  - Shortwave
  - Microwave
History

- Longwave – was the first generation of diathermy devices, developed in the 1920’s.
- Shortwave – developed in the 1930’s and replaced the Longwave because energy could be delivered over an airspace instead of a wet pad.
- Microwave – third generation device that used higher frequencies which decreased the penetration of the energy since higher frequencies are absorbed in superficial tissues. For this reason Microwave was abandoned in favor of Shortwave devices.

History

- For many reasons diathermy is a modality that has been under utilized by clinicians for the past 20 years:
  - safety concerns over leakage of radiation which affects other patients and personnel in the area
  - leakage that affects other electronic devices
  - lack of accurate dose parameters
  - Significant contraindications
  - Expense
  - Lack of research
- Most of the negative connotations associated with diathermy are related to Microwave.

Shortwave Diathermy

- What does it do?
  - Electromagnetic energy is converted to thermal energy:
    - dielectric absorption in insulating tissue
    - induction of circulating currents in the tissue
  - Produces thermal and non-thermal (mechanical) response with physiological and therapeutic effects
• The purpose for the use of diathermy is to significantly heat large areas of deep tissue while minimally affecting superficial tissues.
• The latest generation of SWD devices produce both continuous (CSWD) and pulsed (PSWD) electromagnetic energy.
• These units have been determined to be relatively safe and effective in clinical use.

• SWD units produce high frequency electrical current that produces:
  ➢ Electrical field
    — Charged ions in the tissue move from one pole to the other
  ➢ Magnetic field
    — A conductor is exposed to a changing magnetic field that causes circulating flow of electrons called "eddies."

• SWD devices produce both electrical and magnetic energy and the ratio of one to the other is determined by:
  ➢ Characteristics of the unit
  ➢ Characteristics of the electrodes or applicators
Slide 13

**Induction Field Method:**
- Body area is within a magnetic field produced from a coil in a drum
- Produces high frequency currents within the tissue
  - Effectively heats tissue with low impedance, such as muscles, thus the inductive method is preferable for heating deeper tissues
- Electrodes:
  - Monode "drum"
  - Diplode

Slide 14

**Treatment Tips:**
- Electrode Positioning (Inductive)**:
  - When using the Monode electrode, there should be air space filled with a layer of toweling between the electrode and the skin surface
  - Towel layer (air space between skin and electrode) should be one half inch up to 1.5" of layering with the electrode in contact with the toweling
  - Monode should be placed directly over the area being treated

**Evidence-Based Guide to Therapeutic Physical Agents**

Slide 15

**Capacitive Field Method:**
- Body part is within the electric field between two electrodes forming a "capacitor"
- The "radiation" produces a warming of the body part located within the field
  - Superficial and high density tissues are warmed more effectively: skin, tendon, ligament, joint capsule & bone
- Electrodes:
  - Capacitive plates
  - Flexible rubber electrodes
Slide 16

Treatment Tips:

- Electrode Positioning (Capacitive):
  - Position the required electrodes on the part of the body to be treated according to the medical indication
  - Electrode surfaces must be nearly parallel to the area being treated
  - Correct positioning of the electrodes allows for equal distribution and concentrated heating effect

**Correct**

**Incorrect**

Slide 17

Treatment Tips:

- Electrode Positioning:
  - Local overheating can occur due to electrode constrictions
  - This can be prevented by increasing the distance (e.g., with pillow, felt layers, etc.) of the affected body part

**Correct**

**Incorrect**

Surface warming can be reduced by increasing the electrode distance

Slide 18

**CSWD vs PSWD**

- In recent history there is evidence showing that PSWD is utilized more often than CSWD. It appears that the movement to PSWD is due to concerns over stray radiation that may affect the clinician and other patients.
- The most likely reason for the increased utilization of PSWD is that the bulk of research over the past few years has shown that PSWD can significantly increase the temperature in deep tissues.
Continuous Mode - CSWD:
- Delivers continuous shortwave energy up to 100W

Pulsed Mode - PSWD:
- Delivers shortwave energy in short pulses or bursts
  - Typical pulse width (duration) range: 20 – 400 µsec
  - Typical pulse frequency (repetition) range: 10 – 800 Hz
  - Pulsed output allows mean power to be very low and still provide effective treatment
    - Max peak power: 200W
    - Average (mean) power: 64W

Dosimetry
- How much is enough?
- How much is too much?

Determining the dosage of diathermy for a patient is typically done using two scales:
  - Qualitative
  - Quantitative

Dosage:
- The strength of the electromagnetic field determines the dosage that is applied.
  - Determined by the combination of pulse frequency, pulse width and output power
- Shortwave Diathermy dosimetry is traditionally described as levels I-IV:
<table>
<thead>
<tr>
<th>Heat Perception</th>
<th>Treatment Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>I</td>
</tr>
<tr>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Heavy</td>
<td></td>
</tr>
</tbody>
</table>
Slide 22

**Qualitative Scale**

- The dosage is described by the heat sensation perceived by the patient.
- This is accomplished by the ranking of a four level dose system and heat perception is recorded.

Slide 23

**Dosage Levels According to Schliephake**

- **Dosage I (Lowest):** No perception of heat (Non-thermal)
- **Dosage II (Low):** Slight warming (Mild perception of heat)
- **Dosage III (Medium):** Pleasant warming (Comfortable perception of heat)
- **Dosage IV (Heavy):** Strong warming (Strong but tolerable perception of heat)

Always begin the treatment with a low initial dosage.

Slide 24

**Quantitative Scale**

- The quantitative scale measures the amount of heat generated by the device.
- Quantitative measurement is determined by:
  - Power
  - Pulse frequency
  - Delivery mode (pulsed vs continuous)
  - Duration of treatment
    - Dose = P x T for CSWD
    - Dose = P x T for PSWD
    - This is a measure of what is delivered by the applicator.
Dosage Parameters:

<table>
<thead>
<tr>
<th>Dose</th>
<th>Level</th>
<th>Phase Duration</th>
<th>Frequency</th>
<th>Intensity</th>
<th>Treatment Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Lowest</td>
<td>65 µsec</td>
<td>100 Hz</td>
<td>Max: 150 W Avg: 5 W</td>
<td>20 Minutes</td>
</tr>
<tr>
<td>II</td>
<td>Low</td>
<td>100 µsec</td>
<td>800 Hz</td>
<td>Max: 150 W Avg: 12 W</td>
<td>20 Minutes</td>
</tr>
<tr>
<td>III</td>
<td>Medium</td>
<td>200 µsec</td>
<td>800 Hz</td>
<td>Max: 150 W Avg: 24 W</td>
<td>20 Minutes</td>
</tr>
<tr>
<td>IV</td>
<td>Heavy</td>
<td>400 µsec</td>
<td>800 Hz</td>
<td>Max: 150 W Avg: 48 W</td>
<td>20 Minutes</td>
</tr>
</tbody>
</table>

Always begin the treatment with a low initial dosage.

---

Dosimetry

- There is no linear relationship between the two scales because the perception from one patient to the next will vary.
- Therefore it should be suggested that the clinician utilize both scales in determining dosage.

---

Treatment Tips:

- Treatment times depend upon the required depth and area of treatment
  - Shorter times – hands, forearms, ankles, etc.
  - Longer times – thighs, trunk, abdomen, etc.
- Should any discomfort occur, it may be due to excessive output for the condition being treated
  - In such cases, reduce pulse frequency, it is always better to reduce pulse frequency instead of pulse width.
**Reported Physiological Effects Summary**

- **Electromagnetic Energy Absorption**
  - Increase molecular kinetic energy
  - Cell ion-binding properties, protein synthesis, ATP production

- **Thermal Effect**
  - Increased cell metabolism and function

- **Non-Thermal Effect**
  - Enhanced soft-tissue healing

---

**Thermal Effects**

- Diathermy is not capable of producing depolarization and subsequent contraction of muscle because the wavelengths are too short, therefore the primary effects of diathermy are thermal.
- The high frequency energy creates a vibration of molecules which in turn produces heat.

- The controls for treatment doses are not precise and it is therefore impossible to accurately measure or prescribe the amount of heating the patient will receive.
- The amount of heating is determined by the current density and the resistance of the tissue being treated.
- Heating=Current Density² x Resistance
Temperature increases will cause physiological change:
- Increases of 1°C can reduce mild inflammation and increase metabolism
- Increases of 2° to 3°C will decrease pain and muscle spasm
- Increases of more than 3° to 4°C will increase tissue compliance to stretch (extensibility) allowing the treatment of chronic connective tissue disorders. (Lehmann)

Thermal effects listed in the literature include:
- Increase in tissue temperature
- Increased blood flow
- Decreased joint stiffness
- Cell membrane filtration and diffusion increases
- Increase in metabolism
- Decrease pain
- Muscle relaxation
- Decrease in inflammation

Electromagnetic energy allows damaged cells to return to their normal function.
Non-thermal effects will occur in both CSWD and PSWD.
These non-thermal effects occur at the cell membrane as the electromagnetic energy affects ion attraction and cell function.
Non-Thermal Effects

- Restoring the normal function of damaged cells through repolarization.
- Increase cell growth and division
- Increases the activity of the sodium pump to remove excess sodium. Excess sodium creates a negatively charged environment and the magnetic field will reactivate the pump to regain normal ionic balance in the cell.
- Increase microvascular circulation.

Clinical Effects

- Inflammatory Conditions
  - Assists in removal of cellular debris and toxins
  - Non-thermal:
    - Alters diffusion rate across the cell membrane
  - Thermal:
    - Increases intramuscular metabolism

Clinical Effects

- Blood and Fluid Dynamics
  - Vasodilation increases:
    - Blood flow
    - Capillary filtration
    - Capillary pressure
    - Oxygen perfusion
  - Increased fibroblastic activity and capillary growth
Slide 37

- **Clinical Effects**
  - **Tissue Elasticity**
    - SWD can vigorously heat deep tissues
    - Alters collagen properties, allowing it to elongate
    - Requires stretching during and/or immediately following the treatment
    - Multiple treatments are required

Slide 38

- **Clinical Effects**
  - **Increased Blood Flow**
    - Non-thermal SWD increases rate of phagocytosis
    - Number of mature collagen bundles increase
    - ATP activity increases (assisting tissue regeneration)
    - Necrotic tissue decrease

Slide 39

**Indications:**
- Pain Relief
- Reduction of Muscle Spasm
- Increased Localized Blood Flow (wound healing)
- Joint Contractures
- Decrease of Joint Stiffness
- Chronic Inflammatory or Infective Conditions:
  - Bursitis
  - Tendinovitis
  - Synovitis
  - Chronic Inflammatory Pelvic Disease
Contraindications:

• Any patient with an implanted electronic device such as a cardiac pacemaker, bladder stimulator, spinal cord stimulator, or electrodes for a myoelectric prosthesis, or implanted metallic leads, must not be treated with shortwave diathermy. Do not use on patients who have had an implant in the past unless you are absolutely certain that the implant and all leads in their entirety have been removed. Note that leads are often left implanted after the implant is removed. The effects of the applied high frequency on the pacemaker could cause ventricular fibrillation. Any other persons with pacemakers must also remain outside of the treatment area during shortwave diathermy. No one wearing a cardiac pacemaker should be within 20 feet (inductive field) or 50 feet (capacitive field) of an operating unit.

• Patients whose condition could be negatively affected by heat.

• Patients with hemorrhages or risk of hemorrhage.

• Patients with septic conditions and empyemas.

• Patients with malignant tumors and undiagnosed tumors.

• Implants, areas where implants have been removed, damaged implants, and metal inclusions.

Contraindications:

• Implants that could be impaired by shortwave diathermy irradiation.

• Swellings that still feel warm.

• Thermohyposthesia (diminished perception of temperature differences).

• Thermohyperesthesia (very acute thermoesthesia or temperature sense; exaggerated perception of hot and cold).

• Acute inflammations.

• Severe arterial obstructions (stage III and IV).

• Gynecological disorders involving acute inflammation.

• Permeating irradiation of the thorax in cases of severe heart diseases (heart valve diseases, myocardial insufficiency, myocardiac infarct, severe coronary sclerosis).

• Wetness, perspiration, or damp bandages.

Contraindications:

• Pregnancy, since irradiation of the abdomen could cause teratogenous damage due to alterations of blood circulation and diffusion.

• During the menstrual cycle.

• Over the pregnant or potentially pregnant uterus. Therefore, shortwave diathermy should not be applied over the uterus unless specific assurance can be attained from the patient that she is not pregnant.

• Sudeck’s syndrome, stage I and II.

• Basedow’s disease (irradiation could cause serious states of agitation).

• Varicose veins (irradiation could cause congestive pain).

• Particular care must be taken if the patient’s clothing is wet or damp, since the garments may heat up faster and more intensely than the patient’s body.

• Cardiac conditions.
Contraindications:

• Deep vein thrombosis, phlebitis, varices.
• Synthetic fibers (perlon, nylon, etc.) are characterized by low absorbency, which can cause the skin beneath such fabrics to quickly become moist. Therefore, it is recommended that the body areas to be treated be completely unclothed and the patient's skin dried, particularly where perspiration accumulates in folds of the skin. This applies especially when a higher dosage is being applied. There is no danger, however, when applying shortwave diathermy irradiation to bandaged areas as long as the bandages are completely dry.
• When treating small children, particular care is obviously required due to the low body weight. Very careful dosing and constant observation (manual checks of the skin temperature while the unit is switched off) are necessary.
• The output power must always be set according to the subjective response of the patient. Therefore, special care must be taken in case of patients with a diminished capacity for perception of heat (refer to “Dosage Levels According to Schliephake”).
• Since the effects of high-frequency fields on unborn life have not yet been sufficiently researched, we recommend that operators who are pregnant do not remain in the immediate vicinity of the applicator when the unit is activated.

Contraindications:

• It is advisable to post warnings for wearers of pacemakers in the rooms where high-frequency therapy (e.g. shortwave diathermy) is applied.
• A distance of at least 20 feet must be maintained between the unit and any low-frequency therapy that is being used.
• Arterial disease, circulatory insufficiency.
• Over eyes.
• Over reproductive organs.
• Over cardiac pacemakers and defibrillators, cochlear implants, bone growth stimulators, deep brain stimulators, spinal cord stimulators, and other nerve stimulators.
• Over open lamina (after laminectomy, spina bifida).
• Over superficial endoprosthesis or metal implants.
• Neoplastic tissues or space occupying lesions.

Contraindications:

• Directly over the carotid sinuses, cervical stellate ganglion, or Vagus nerve located in the anterior neck triangle.
• Direct application over cancerous tumors or lesions due to its potential to increase blood flow to the area of malignancy.
• Occlusive vascular disease, such as arteriosclerosis obliterans and thromboangitis obliterans, in which occlusive occlusion and ischemia are evident.
• Directly over the epiphysis of growing bones in children and adolescents because shortwave diathermy therapy may enhance or inhibit bone growth.
  *NOTE:* The mean age for skeletal maturity is 15 ½ years in females and 17 ½ years in males.
• In the presence of systemic or local infection (sepsis, Osteomyelitis, tuberculosis) or if the patient has an elevated temperature.
Contraindications:

- In areas where metal is present due to eddy current generation of excessive and uneven heat distribution. Metal objects within the treatment area should be removed and placed outside the electromagnetic field. These include, but are not limited to:
  - Metal in the environment:
    - Within one foot of beds, treatment tables, standard chairs, wheelchairs, step stools, sinks, tables, dressers, countertops, and surgical lighting.
    - Within 20 feet of electronically controlled medical devices such as CPM devices, electric wheelchairs, electrotherapy devices, or other electrical systems, computers, etc.
  - Metal near the patient:
    - Jewelry, body piercing earrings, watches, keys, belt buckles, underwear, bra, hearing aids, zippers in clothing or pillow cases.
  - Metal objects within the treatment area that cannot be removed should be avoided. These include, but are not limited to:
    - External metal: orthodontic braces, dental fillings, staples, external fixation devices.
    - Internal metal: valves, joint replacements, metal IUDs, shrapnel, metal implants, internal fixation devices, rods, plates, screws, wires, etc.

**NOTE:** If there is a scar in or near the treatment area, check with the patient and/or the patient's chart to determine if there is metal under the scar.

---

**Diathermy Vs Ultrasound**

- Surveys of clinicians reveal that 94% of them use ultrasound while only 0.6% use diathermy on a daily basis. (Lindsay et al)

  **WHY??**
  - Are they more comfortable with US?
  - Is a diathermy unit available?
  - Is there a fear of diathermy?

---

**Diathermy Vs Ultrasound**

- Research has shown:
  - Due to the size of the drum applicator diathermy can heat an area 25 times larger than a typical ultrasound treatment.
  - Heating remains constant as the drum is stationary not moving as in US where the heating fluctuates.
  - Muscle heated with diathermy will retain heat 60% longer than 1mhz US. (Draper) This increases the stretch window.
Slide 49

- **Ultrasound and Shortwave Diathermy Comparison**

<table>
<thead>
<tr>
<th></th>
<th>Ultrasound</th>
<th>Shortwave Diathermy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy type</strong></td>
<td>Acoustical</td>
<td>Electromagnetic</td>
</tr>
<tr>
<td><strong>Tissue heated:</strong></td>
<td>Collagen-rich</td>
<td>Collagen-rich, adipose tissue</td>
</tr>
<tr>
<td><strong>Tissue volume:</strong></td>
<td>Small (20 cm²)</td>
<td>Large (200 cm²)</td>
</tr>
<tr>
<td><strong>Temp increase:</strong></td>
<td>1 MHz: &gt; 6.3 °F</td>
<td>1 MHz: &gt; 7 °F</td>
</tr>
<tr>
<td><strong>Heat retention:</strong></td>
<td>3 min</td>
<td>&gt; 5 min</td>
</tr>
</tbody>
</table>

C = Capacitive method  
I = Induction method

Slide 50

- **Advantages of Shortwave Diathermy**
  - **Deep** penetration, up to 5 cm  
  - **Hands-free** Application - You can use it while attending to another patient, which allows you to manage your time in the clinic  
  - **It covers** large areas  
  - It can heat the deeper tissue **without heating the superficial tissue**  
  - **Non-contact** application possible - e.g. sensitive tissues / lesions etc...

Slide 51

- Thank you
Slide 1

Low Level Laser Therapy

Tool in the Toolbox

Slide 2

Physical Agents

The miracle is not in the medicine but in the patient’s body — in the vis medicatrix
naturae, the recuperative or self-corrective energy of nature. What the treatment does is
to stimulate natural functions or to remove what hinders them.

C.S. Lewis, Miracles, 1940

Slide 3

Selecting Physical Agents

- What is the desired effect?
  - Heating
  - Nerve depolarization
  - Metabolic stimulation
- What is the target tissue?
- What parameters will achieve the effect in the tissue?
- What evidence supports this?
  - Theoretical
  - Case studies
  - RCT with control
Slide 4

Evidence Based Practice

- Literature Support
- Clinician Experience
- Patient Experience


Slide 5

LASER

- Light (photons)
- Amplification by Stimulated Emission of Radiation

Slide 6

Common Laser Identities

- Phototherapy
- Light Therapy
- Laser
- Cold Laser
- Soft Laser
- Infrared
- Near Infrared
- Low Powered Laser
- Low Level Laser Therapy (LLLT)
- Anodyne Therapy
**Introduction**
- Low level laser therapy (LLLT) is the best term for the type of lasers used in rehab.
- The instrument is considered a “Therapeutic Laser.”
- Non-thermal modality (≤36.5º C)
- Simply another form of energy that can be used to trigger physiologic change.

---

**Laser Classification**

<table>
<thead>
<tr>
<th>Class</th>
<th>Power</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>&lt; 0.5 mW (very low)</td>
<td>Laser printer, CD players</td>
</tr>
<tr>
<td>Class 2</td>
<td>&lt; 1 mW (low)</td>
<td>Laser Pointer</td>
</tr>
<tr>
<td>Class 3A</td>
<td>&lt; 5 mW (low)</td>
<td>Laser pointer, very low power LLLT devices</td>
</tr>
<tr>
<td>Class 3B</td>
<td>&lt; 500 mW (medium)</td>
<td>Low level Laser Therapy</td>
</tr>
<tr>
<td>Class 4</td>
<td>&gt; 500 mW (high)</td>
<td>Surgical Lasers</td>
</tr>
</tbody>
</table>

---

**Laser Classification**
- Laser devices are classified based on power output (mW) and on relative risk for causing biological damage (especially retinal damage when eye is directly exposed to laser beam).
- Class 3b lasers are quickly becoming the standard in the rehab field.
- Higher power allows for:
  - Shorter treatment times
  - Enhanced depth of penetration.
CAUTION!

Never direct laser beam towards the eye.
Both patient and clinician should wear protective goggles
that are wavelength specific to the device that is being
used.
Note: lasers in infrared spectrum are invisible to the
human eye, hence the unprotected eye will not have the
normal protective blink reflex.

Laser Classification

Historical Background

Albert Einstein

- Provided basic science and theory
Slide 13

Theodore Maiman

1960: Built the first laser with a polished ruby

Slide 14

Ali Javan

1960: Invented the first gas laser – HeNe

Slide 15

Endre Mester

The “father” of LLLT

60s: Initial focus was to destroy tumors - didn’t work, but...

Photobiostimulation: found that low intensity laser, without heating, stimulated wound healing
Mester’s Work
- Changed his research agenda to tissue healing applications of laser
- Research showed faster healing of:
  - Experimental skin defects
  - Diabetic skin ulcers
  - Venous insufficiency ulcers
  - Bedsores
- Note: used Ruby Laser (red light)

Time Line
- 1965 – Semiconductor laser diodes sources discovered
- 1979 – Introduction of Gallium Aluminum Arsenide
- 1981 – First self contained hand-held system
- 1980’s – SLD introduced as diodes evolve
- 1990’s – Therapeutic devices became higher powered

Tiina Karu
- 60s-70s: work in former Soviet Union, Hungary, Japan and China
- 80s: in W. Europe
- Started with lower power than now available
- Went to higher power to decrease treatment time
- Started the trend to use higher dosages
Therapeutic Lasers in US

2/2002: FDA approval of one device for Carpal Tunnel Syndrome
- 830nm (IR)
- 90mW (3 x 30)

6/2002: FDA approval of other device for head and neck pain
- 635 nm (red)
- 10mW

PTs, OTs, AT’s, chiropractors, vets – for musculoskeletal problems, to reduce pain and swelling and promote healing
Dermatologists – for skin ulcers
Rheumatologists – for pain relief
Dentists – for tissue healing and pain relief

Physics of Laser Light
Slide 22

Components of Laser
1. Laser Chamber
2. Lasing Medium
3. Pumping system (energy input to laser)
4. Applicator (laser probe)

Slide 23

Laser Chamber
- Tube with mirrors on both ends
  - One mirror is semi-permeable
  - Mirror on opposite end is totally reflective
- Light is emitted from the semi-permeable end
- Chamber houses the "lasing medium"

Slide 24

Lasing Media
- Excitation of atoms within the lasing medium creates the amplification of light
- Examples:
  - Helium-Neon (HeNe)
  - Gallium-Arsenide (GaAs)
- Contemporary lasers commonly use Gallium Aluminum-Arsenide (GaAlAs) as a media
Slide 25

Lasing Media

- The lasing medium properties determine the laser's wavelength.
- Manufacturers are able to customize laser applicators to a specific wavelength by manipulating the ratio of gallium and aluminum in the medium.

Lasing Media

Slide 26

Laser Wavelength

<table>
<thead>
<tr>
<th>Category</th>
<th>Wavelength</th>
<th>Laser Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helium Neon (HeNe)</td>
<td>63.3 nm</td>
<td>Visible Red Gas</td>
</tr>
<tr>
<td>Gallium Aluminum Arsenide</td>
<td>780-890 nm</td>
<td>Infrared Semi-Conductor (most effective)</td>
</tr>
<tr>
<td>Gallium Arsenide (GaAs)</td>
<td>904 nm</td>
<td>Infrared Semi-Conductor</td>
</tr>
</tbody>
</table>

Slide 27

Pumping System

- Power source applies energy input into the lasing chamber.
- Atoms in the lasing medium are stimulated within the enclosed chamber.
- Electrons are promoted to higher energy levels.
- "Population inversion": state in which the majority of atoms have reached their excited state.

Pumping System
Laser Production: Summary

Regular white light from a light bulb scatters light of multiple wavelengths in multiple directions.

Laser beams are concentrated light of a single wavelength, aimed in a single direction, with all waves in phase with each other.

Unique Properties of Laser:

- Regular white light from a light bulb scatters light of multiple wavelengths in multiple directions.
- Laser beams are concentrated light of a single wavelength, aimed in a single direction, with all waves in phase with each other.

Properties Laser Radiation

- Laser
  - Monochromatic
  - Coherent
  - Collimated
**Slide 31**

**Monochromaticity**
- Monochromatic
  - One single color
  - One single frequency
  - One single wavelength

**Slide 32**

**Coherence**
- Coherent
  - All waves are in phase
  - Light waves match identically in timing and spacing

Note: Super-Luminous diodes (SLD) and Light emitting diodes (LED) do not possess coherence, they produce a divergent beam.
Slide 34

Note the synchronicity of the waves

Coherence

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Slide 37

Electromagnetic Spectrum

Cell damage - Heat

Electromagnetic Spectrum

ROY - G - BIV

Slide 38

<table>
<thead>
<tr>
<th>Wavelength Range (nanometers)</th>
<th>Perceived Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>340-400</td>
<td>Near Ultraviolet (UV; Invisible)</td>
</tr>
<tr>
<td>400-430</td>
<td>Violet</td>
</tr>
<tr>
<td>430-500</td>
<td>Blue</td>
</tr>
<tr>
<td>500-560</td>
<td>Green</td>
</tr>
<tr>
<td>560-620</td>
<td>Yellow to Orange</td>
</tr>
<tr>
<td>620-700</td>
<td>Orange to Red</td>
</tr>
<tr>
<td>Over 700</td>
<td>Near Infrared (IR; Invisible)</td>
</tr>
</tbody>
</table>

Slide 39

Electromagnetic Spectrum

- Wavelengths between approx 600 – 1000 nanometers (nm) are typically used in LLLT
- Visible: 600 – 700 nm
- Invisible (Infrared): 700 – 1000 nm
Biology of light therapy

Light enters the cell
Certain molecules called chromophores react to it
Chromophores are in all tissues
Show wavelength specificity
Photochemical reaction triggered
Desirable physiological effects and clinical treatment outcomes

Physiologic Effects
- Increases circulation
- Increases lymphatic activity
- Stimulation of collagen synthesis
- Stimulation of ATP production
- Acceleration of the inflammatory response
- Decreased inflammation
- Decreased pain
- Increased lymphocyte activity
- Increase macrophage responsiveness
- Decrease cells for fibrinogen
- Increased presence of macrophages
- Stimulates fibroblastic activity
- Accelerates wound healing
Slide 43

LLLT Physiological Effects

- Light (Photons) Applied to Tissue
- Absorption in Mitochondria
  - ↑ ATP Synthesis
  - ↑ Protein Synthesis and Cell Proliferation
- Tissue Repair and Pain Control

Slide 44

- LASER
  - Beam of Laser light (photons) striking skin
  - Absorption of photons by chromophores
  - Photobiomodulation
  - Photobiostimulation
  - Photobioinhibition
  - Wound Healing
  - Pain Modulation

Slide 45

- Biochemical Effect on the Cellular Level
  - Light energy penetrates skin surface and underlying tissue
  - Absorbed by intracellular molecules and mitochondria
  - Transforms into biochemical energy
  - Triggers reaction within cell leading to accelerated healing and pain attenuation
Slide 46

**Intracellular effects**
- Stimulation of ATP
- Increased cell membrane permeability
- Stimulation of respiratory chain
- Increased DNA synthesis
- Block prostaglandin
- Increased levels of beta endorphins and serotonin
- Accelerates collagen synthesis

Slide 47

**FDA Clearances**
- Adjunctive use for temporary relief of wrist or hand pain associated with carpal tunnel syndrome
- Temporary increase in local blood circulation
- Temporary relief of minor muscle and joint aches and pains
- Stiffness and relaxation of muscle spasms
- Muscle spasms
- Minor pain and stiffness associated and arthritis

Slide 48

**Indications**
- Tissue healing
- Pain control
- Acute injuries/trauma
- Inflammatory conditions
- Degenerative disorders
- Neurological disorders
**Slide 49**

**Contraindications**
- Over eyes
- Cancer
- Photophobia (sensitivity to light)
- Direct irradiation over the fetus or the uterus during pregnancy
- When using photosensitizing medication
- Over hemorrhage
- Over thyroid or endocrine glands

**Slide 50**

**LLLT over Growth Plates**
- No peer-reviewed studies have identified any adverse effects of the use of LLLT over open growth plates
- Sometimes listed as a contraindication in operator manuals and in textbooks
- May therefore be prudent recommendation to not irradiate directly over growth plates

**Slide 51**

**General comments**
- Do not treat through clothing
- Use 50-75% of recommended dosage when treating over dark tattoo or over dark pigmented skin
### Slide 52

**Treatment Parameters**

- Light source
- Wavelength
- Power
- Time
- Duty cycle

### Slide 53

**Laser Applicators**

- Single diode
- Cluster

### Slide 54

**Light Sources**

- Laser Diode
- Super-Luminous Diode (SLD)
- Light Emitting Diode (LED)
- Cluster probes (combinations)
Slide 55

Depth of Penetration

LED
SLD
LASER

---

Slide 56

Laser diode

- Collimated light (very focused)
- Monochromatic
- Coherent
- Deeper penetration than LED and SLD

---

Slide 57

Super-Luminous Diodes (SLDs)

- Collimated
- Narrower frequency range and beam angle than an LED but wider than a Laser diode
- Less divergent than LED's
- Brighter Diode than LED's
- Provides more energy than LED's

---
**Slide 58**

**Super-Luminous Diodes (SLDs)**
- Monochromatic
- Non-coherent
- Depth of penetration is less than laser diode, but typically greater than LED's
- Indicated for treatment of superficial tissue
- 600 nm – 1000 nm
- Depth of penetration 2-3 cm

**Slide 59**

**Light Emitting Diode (LED's)**
- Non-collimated (less focused)
- Non-coherent
- Minimal penetration (several mm)
- Indicated for treatment of very superficial tissue

**Slide 60**

**Light Emitting Diode (LED's)**
- Single color with a narrow range of wavelength
- 600 nm – 700nm
Slide 61

<table>
<thead>
<tr>
<th>Laser</th>
<th>LED/SLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrared</td>
<td>LED: visual red only</td>
</tr>
<tr>
<td>Higher energy</td>
<td>SLD: mixture</td>
</tr>
<tr>
<td>Higher Power</td>
<td>Wider beam</td>
</tr>
<tr>
<td>Single frequency</td>
<td>Treats larger area</td>
</tr>
<tr>
<td>700 – 1000 nm</td>
<td>Narrow range of frequencies</td>
</tr>
<tr>
<td>Deeper Penetration</td>
<td>Superficial penetration</td>
</tr>
<tr>
<td>~ 5 cm</td>
<td>LED ~ 1 cm</td>
</tr>
<tr>
<td>More expensive</td>
<td>SLD ~ 2 – 3 cm</td>
</tr>
<tr>
<td></td>
<td>Lower cost</td>
</tr>
</tbody>
</table>

Slide 62

Laser & LED Beam Profiles

- Laser: Wider beam, treats larger area, superficial penetration
- LED: Narrow range of frequencies, superficial penetration

Profile from above

Slide 63

Cluster Probes

- Laser diodes can be combined with SLD’S and LED’S to form a diode cluster
- Important to know what the cluster is comprised of
- Indicated for treating larger areas
Slide 64

**Treatment Parameters**

- 4 key parameters to determine dosage and penetration depth:
  - Wavelength (nm)
  - Power (mW)
  - Energy density (J/cm²)
  - Continuous or Pulsed

Slide 65

**Putting it Together!**

Slide 66

**Why Add Laser Therapy?**

- Comfortable for the patient (sub-sensory)
- Non-Invasive
- Minimal thermal effects/few contraindications
- Effects can be cumulative and immediate
- Quick treatment times
- Complimentary to manual therapy techniques
Application Technique

- Clean skin with alcohol
- Do not apply lotions and gel
- Break down treatment area into cm squares (hypothetical grid)
- Treat each point within “grid”
- Use a stationary technique
- Maintain firm, direct contact directly with intact skin to increase penetration

Increasing Penetration

- Longer wavelengths
- Collimated Beam (laser not SLD/LED)
- Increased power
  - 100 mW = for superficial target tissues (<1 cm depth)
  - 200 mW = for medium depth target tissue (1-2 cm depth)
  - 300 mW = for deeper target tissue (>2 cm depth)
- Apply firm pressure (shunts blood away from probe)
- Apply perpendicular to tissue
Application Technique
- Tip in contact with the skin
- Perpendicular to the target tissue
- Gridding technique is the most common

Treatment Protocols

Chronic Wounds
- Applicator: single diode applicator or cluster applicator
- Wavelength: 632.8 or 820 nm (Tuner, 2004)
- Dosage: 1-6 J/cm²
- Application: continuous output
- Area: in and around wound bed
- Frequency: 2 x per week minimum
- Claimed results: accelerated healing rate, faster wound contraction

Wounds: Clinical Notes

- Tuner (2004): 632.8 nm for superficial wounds
- 820 nm for deeper wounds
- 1.0-6.0 J/cm² reportedly effective in accelerating tissue healing (4 J/cm² most frequently)
- Single diode applicators useful for wound margins (intact skin)
- Points of application no more than 2 cm apart

Points of application no more than 2 cm apart

Wounds: Clinical Notes

Before LLLT

After 6 wks LLLT

Treatment Protocols

Definition: Triggerpoints

- Point in soft tissue, usually a muscle causing referred pain
- Each muscle has its own set of standard points
- If left untreated it can easily become chronic
- Can relatively easily be resolved with treatment
- If present for long enough, one TP may lead to development of others (satellite points) in referred pain zone

Points of application no more than 2 cm apart
Slide 76

Types of Triggerpoints

- Two types of triggerpoints:
  - Active TP – causes spontaneous referred pain
  - Latent TP – only causes referred pain on stimulation (pressure, stretch, contraction)

- Latent TPs occur in most individuals

Slide 77

LLLT for Triggerpoints

- Applicator: single diode applicator or cluster applicator
- Wavelength: 820 nm
- Dosage: 5-12 J/cm²
- Application: continuous output (may pulse if acute)
- Area: over center of trigger point
- Frequency: 3 x per week for minimum of 2 weeks
- Claimed results: decreased pain, elevated beta-endorphin levels, decreased trigger point activity


Slide 78

TPs: Clinical Notes

- Dosage of < 5 J/cm² may decrease pain but does not elevate beta-endorphin level
- Baxter (2003) suggests a higher dosage of 10-12 J/cm² for recalcitrant trigger points
- Treat the center of the trigger point with the single diode applicator and the referred pain area with the cluster applicator
- Test-retest trigger point via palpation pre- and post-treatment
Soft tissue injury

**Slide 80**

**Acute Soft tissue Injury**
- Applicator: cluster applicator; single diode applicator for small areas
- Wavelength: 820 nm
- Dosage: 4-8 J/cm²
- Application: pulsed output (<100 Hz)
- Area: over traumatized tissue
- Frequency: up to 3 x per day
- Claimed results: decreased pain, accelerated inflammatory response

*Acute ST Injury: Notes*

- Most appropriate frequency has not yet been established.
- Increase frequency to the kilohertz range as inflammation passes into subacute phase
- Initiate treatment as soon as possible after injury
- Apply firm contact as tolerated
- As a general guideline, use 600-700 nm for superficial lesions, 700-1000 nm for deeper lesions
Chronic Soft Tissue Injury
- Applicator: cluster applicator; single diode applicator for small areas
- Wavelength: 820 nm
- Dosage: 12 J/cm²
- Application: continuous output, over traumatized tissue
- Frequency: 3 x per week
- Claimed results: decreased pain, accelerated inflammatory response

Chronic ST Injury: Notes
- Increase dose as patient response improves
- Use minimum dose necessary to elicit desired response
- Apply firm contact as tolerated
- As a general guideline, use 600-700 nm for superficial lesions, 700-1000 nm for deeper lesions

Treatment Protocols
Neuralgia
Pain control
Neuralgia
- Applicator: single diode applicator for small areas, cluster applicator for larger areas
- Wavelength: 820 nm
- Dosage: 10-12 J/cm²
- Application: continuous output
- Area: over several points along the course of the nerve root and peripheral nerve
- Frequency: 3 x per week
- Claimed results: decreased pain


Neuralgia: Notes
- Treat dermatomes and areas of referred pain with cluster applicator
- Since multiple points must be irradiated, total treatment time will be longer
- Higher powered laser diodes and the use of cluster applicators will shorten this time
- As a general guideline, use 600-700 nm for superficial lesions, 700-1000 nm for deeper lesions

Pain Control
- Applicator: single diode applicator
- Wavelength: 830 nm
- Dosage: 6-12 J/cm² (acute-chronic)
- Application: continuous output
- Area: on painful area
- Frequency: 3 x per week
- Claimed results: decreased pain ratings

Pain Control: Notes
- Increase dosage as inflammatory response subsides
- Dosage of < 5 J/cm² may decrease pain, but does not elevate beta-endorphin level (Laakso, 1994)
- Baxter (2003) suggests a higher dosage of 10-12 J/cm² for recalcitrant trigger points
- Treat the center of the tender or trigger point with the single diode applicator and the referred pain area with the cluster applicator

Treatment Protocols
Inflammation
Chronic Joint Disorders

Applicator: single diode applicator for small areas, cluster applicator for larger areas
Wavelength: 980 nm
Dosage: 2-5 J/cm²
Application: pulsed output at 5000 Hz
Area: over entire inflamed tissue
Frequency: 3 x per week
Claimed results: decreased inflammation, decreased pain and swelling, improved ROM

Inflammation: Notes
- Apply firm contact as tolerated
- Applying pressure to the applicator forces blood away from under the applicator which increases penetration and absorption of the light energy into the tissue
- Initiate treatment as soon as possible after injury
- Increase dosage through range as inflammatory response subsides

Chronic Joint Disorders
- Applicator: single diode applicator for small areas, cluster applicator for larger areas
- Wavelength: 820 nm
- Dosage: 0.5 J/cm² at 2 mm depth (fingertip, TMJ, etc.), 6 J/cm² at 4 mm depth (knee, etc.), 12 J/cm² at 12 mm depth (spine)
- Application: continuous output
- Area: over painful joint surface
- Frequency: daily or every other day, 2-3 weeks
- Claimed results: decreased pain, improved ROM, improved function

Chronic Joint: Notes
- Irradiate entire joint surface
- Since multiple points must be irradiated, total treatment time will be longer
- Higher powered laser diodes will shorten this time
- Bjordal et al (2003) recommend increasing dosage for treatment of deeper tissue in lumbar spine (based on patient response and clinical judgement)
- Tuner (2004) cautions that the use of high dosages in chronic conditions may temporarily exacerbate symptoms

Chronic Joint Disorders
THANK YOU