## TABLE OF CONTENTS

- **LASER THERAPY EXPLAINED**
  - INTRODUCTION ..................................................... 5
  - FREQUENTLY ASKED QUESTIONS ................................ 8
  - LASER HISTORY AND SCIENCE .................................. 10
  - OPTIMIZING LASER PHOTOTHERAPY .............................. 12
  - PHYSIOLOGICAL AND BIOLOGICAL EFFECTS OF LASER THERAPY ............................................. 21
  - TIPS TO IMPROVE K-LASER® TREATMENT RESULTS .......... 22
  - K-LASER® THERAPY DELIVERY TECHNIQUES .................. 24
  - LASER EYE SAFETY FOR CLASS IV THERAPY LASERS .......... 25
  - CALCULATING THE ENERGY DENSITY OF A THERAPY LASER ......................................................... 28
  - LASER THERAPY DOSE CALCULATION SIMPLIFIED .......... 30
  - DOSAGE DISCUSSION AND EXAMPLES ........................... 31
  - FREQUENCY MODULATION DISCUSSION ......................... 34
  - INTENSE SUPERPULSE DISCUSSION ................................ 37
  - WAVELENGTH AND TISSUE PENETRATION ....................... 39
  - TREATMENT PLAN FORMULATION .................................. 41
  - DYNAMICALLY REFINED THERAPY (DRT) ......................... 43
  - BREAKING DOWN YOUR K-LASER® DEVICE ..................... 44
  - HOW TO WRITE A CASE STUDY ........................................ 46
  - ATLAS OF K-LASER® TREATMENTS .............................. 48

## ATLAS OF K-LASER® TREATMENTS

### HEAD TREATMENTS:
- DIAGNOSIS ..................................................... 51
- TREATMENT TECHNIQUES ........................................... 51
- WHAT TO EXPECT ................................................... 51
- RECOMMENDED TREATMENT PLAN .............................. 51

### CERVICAL TREATMENTS:
- DIAGNOSIS ..................................................... 53
- TREATMENT TECHNIQUES ........................................... 53
- WHAT TO EXPECT ................................................... 53
- RECOMMENDED TREATMENT PLAN .............................. 53

### SHOULDER TREATMENTS:
- DIAGNOSIS ..................................................... 55
- TREATMENT TECHNIQUES ........................................... 55
- WHAT TO EXPECT ................................................... 56
- RECOMMENDED TREATMENT PLAN .............................. 56
TABLE OF CONTENTS

ELBOW TREATMENTS:
- Diagnosis ........................................ 57
- Treatment Techniques ....................... 57
- What to Expect ................................ 58
- Recommended Treatment Plan ............. 58

WRIST / HAND TREATMENTS:
- Diagnosis ........................................ 59
- Treatment Techniques ....................... 59
- What to Expect ................................ 60
- Recommended Treatment Plan ............. 60

THORACIC TREATMENTS:
- Diagnosis ........................................ 61
- Treatment Techniques ....................... 61
- What to Expect ................................ 62
- Recommended Treatment Plan ............. 62

LUMBAR TREATMENTS:
- Diagnosis ........................................ 63
- Treatment Techniques ....................... 63
- What to Expect ................................ 64
- Recommended Treatment Plan ............. 64

HIP / SACROILIAC TREATMENTS:
- Diagnosis ........................................ 65
- Treatment Techniques ....................... 65
- What to Expect ................................ 66
- Recommended Treatment Plan ............. 66

KNEE TREATMENTS:
- Diagnosis ........................................ 67
- Treatment Techniques ....................... 67
- What to Expect ................................ 68
- Recommended Treatment Plan ............. 68
# Table of Contents

## Foot / Heel Treatments:
- Diagnosis ........................................... 69
- Treatment Techniques .......................... 69
- What To Expect ..................................... 70
- Recommended Treatment Plan ............... 70

## Ankle Treatments:
- Diagnosis ........................................... 71
- Treatment Techniques .......................... 71
- What To Expect ..................................... 72
- Recommended Treatment Plan ............... 72

## Appendices
- Glossary of Terms .................................. 73
- Further Reading ..................................... 80
INTRODUCTION

Welcome to K-LaserUSA! Your K-Laser® K-CUBE SERIES™ is the most advanced Class IV Therapy Laser available, with the power and versatility you need to treat a wide variety of conditions. The K-Laser® K-CUBE SERIES™ has been designed for ease of use and maximization of your clinical results.

First FDA cleared in 2002, therapeutic lasers are the fastest growing modality in both the Veterinary and Human Medical markets. They are gaining popularity for their ease of use, cost-effectiveness, and unparalleled clinical efficacy across a broad range of therapeutic applications for pain management and wound healing. K-LaserUSA has been at the top of this industry since 2005, and has continued to evolve the technology to fit the ever-growing research of laser biostimulation. Today, the bar has been set many steps higher as K-LaserUSA introduces the K-CUBE SERIES™ laser, the world’s first 4-wavelength therapeutic laser.

Laser light of different wavelengths influences different biological targets in the body. To this point, engineering difficulties have limited clinical efficacy of including multiple-wavelength light sources within compact, practical equipment. Current state-of-the-art therapy lasers can produce two independent wavelengths strategically selected in the part of the light spectrum where the body is most transparent (for highest penetration capabilities) and where the absorption of useful biological enzymes is high.

K-LaserUSA has not simply taken the next step, but has pioneered a full paradigm shift towards robust laser technology that combines high-level research with engineering magic to make this already successful modality more compact, more intuitive, more powerful, and more far-reaching than any of its predecessors.

We know that different tissue-types in our bodies respond better to different laser parameters, but until now, our treatment options have been limited by how much we can fit into one device and how precisely we could control the temperature and efficiency of our diodes. From a hardware perspective, the optic coupling, cooling mechanisms, battery life, and memory capacity of the K-Laser® K-CUBE SERIES™ are head and shoulders more advanced than any laser out there, including our current model.

High-level technology is useless unless it is easy to use by the clinician. We started from scratch and worked hard to organize the K-Laser® K-CUBE SERIES™ software based on what doctors really know about the patient and condition, and combined everything we have learned from the current literature to narrow down the optimal parameters appropriate for that treatment.

The K-Laser® K-CUBE SERIES™ can deliver therapeutic laser energy in a variety of modes: continuous wave; Frequency Modulated (Hz) at a range of frequencies from 1 to 20,000Hz; or Intense SuperPulsed mode, a feature which is unique to K-Laser® Devices. The therapy presets pre-programmed in the K-Laser® K-CUBE SERIES™ deliver a combination of CW, Hz, and ISP modes that are most appropriate for the specific conditions.

The K-Laser® K-CUBE SERIES™ software lets you select the skin color of the patient you are treating. The therapy protocols have been written to take skin pigmentation into account, adjusting the delivery mode, power, and treatment time to deliver the most effective K-Laser® Treatment for that particular patient.
INTRODUCTION

In choosing a preset, it would not be harmful if you applied a 'dark skin' preset on a light skinned patient, and vice versa. Preset selection can at times be a process of trial and error in choosing the one that will give the best therapeutic outcome for the particular patient.

Along with the anatomical presets, there is also a section of ‘Additional Treatments’ that can be used to address specific indications such as soft tissue injury and edema.

As a beginner K-Laser® Device user, we suggest that you utilize the preset therapy protocols. These protocols have been designed by our team of doctors and scientists to maximize your clinical outcomes, without you having to worry about all of the science behind it. Simply select the protocol for the body part, pain level and chronicity – and apply the beneficial K-Laser® Treatment to the patient.

Once you are an experienced K-Laser® Therapy clinician, you can modify the existing protocols, or even create your own.

The K-Laser® K-CUBE SERIES™ also features the ability the save, search, and view individual treatments by patient name. Within every treatment protocol selection screen, there is a "Patient Name (optional)" button. When you tap this button (and you can do so at any time without modification of any protocol), a full virtual keyboard (equipped with letters, numbers, and a space bar) will appear for you to enter the patient’s name. There is no character limit on names.

Once you have entered a name for a patient, that name will appear where the "Patient Name (optional)" button was. If you were to tap on this button again, you could edit the name you typed. As you progress from choosing a protocol to administering it (by tapping the yellow triangle ‘go’ button), the patient’s name remains along the top of the treatment delivery screen.

This assigned name now serves as the main storage label for all treatments performed on this patient. If you were to type a name of an existing patient, you will be notified as such and given the opportunity to cancel (and change the name you just typed), or add the treatment you are about to perform to the file of the patient with this name (if in fact you forgot that you had already saved this patient once before).

From the main screen, if you tap on the middle circular button (with a rolodex icon), every patient name you have ever saved appears in alphabetical order. Along each side of the screen you will see tabs with groups of letters to make searching for an existing patient’s name even easier.

Once you find the name of a patient, you have several options. If you simply want to treat the patient, tap on the patient’s name, and you will be forwarded to the screen that allows you to choose the type of protocol to administer. To access the other options, simply press and hold on the patient’s name. This will reveal the sub-menu of options.

If you wish to rename the patient or delete its entry, you have those options listed there. If instead you wish to view all of the past treatments done on this patient, you can tap on "History" and all past treatments done under this patient's name will be displayed in reverse chronological order (most recent first). Furthermore, if your goal is to
store this patient's data on a computer, you will find an "export" icon at the bottom of
the screen, which will prompt you with a choice of file format in which to save this data.
You would then be prompted to insert a USB stick into the USB drive to complete the download
of this patient's full history.

The K-Laser® Device is a powerful tool and you should resist the temptation to increase the
wattage for every patient. There are certainly times when it is clinically indicated to use high
power, but in many cases using too much power can unnecessarily exacerbate the patient's
condition.

Remember that K-LaserUSA has experienced clinicians available if you need advice on the spe-
cific settings to use. There are resources posted on the K-LaserUSA Online Resource portal, such
as recorded client conference calls. These let you listen to the clinical questions and comments
from other K-Laser® Therapy practitioners. And always remember free telephone support is
available by contacting K-LaserUSA at 866-595-7749.
Frequently Asked Questions

Q: Can a pregnant woman give K-Laser® Treatments?
A: Yes. There is a small amount of infrared laser light that is reflected back from the patient. First of all, this reflected infrared laser light is not harmful. And your clothing will completely block it, and there is no exposure to the fetus.

Q: Do K-Laser® Treatment technicians need to wear dosimetry badges?
A: No. X-rays and infrared are on opposite sides of the electromagnetic spectrum. X-ray photons are very high energy and can ionize molecules, damage DNA and in high enough doses can cause cancer. Infrared photons are much lower in energy. They cannot ionize molecules, and therefore do not damage tissue. You do not need to wear a dosimetry badge when operating the K-Laser® Device.

Q: What is a “Class 4” laser?
A: Lasers are given a class number based on how powerful they are, with the numbers running from 1 thru 4. Any laser with power greater than half of a Watt (or 500 milliWatts) is a Class 4 laser. Examples include the K-Laser® Therapy device, surgical and industrial lasers. Your K-Laser® Device is at the very low end of the Class 4 laser range, and the beam is allowed to spread out, so the effect is therapeutic, not cutting or damaging.

Q: Do we need any protective gloves or clothes to give K-Laser® Treatments?
A: No. The K-Laser® Device uses infrared treatment beams. Infrared photons of light are non-ionizing, and do not expose the hazard of X-rays.

Q: Can I treat a patient’s head and sinuses?
A: Yes. There are four absolute contraindications for laser therapy treatments: directly into the eye; directly over the thyroid gland; and no treatment for a patient who is pregnant or has cancer. You can treat over the skull and sinuses. Bone is actually very transparent to infrared laser light, and K-Laser® Treatments for sinus problems/seasonal allergy symptoms/etc can be very effective.

Q: Can I treat a patient with metal implants?
A: Yes. Laser is light, and would be reflected from the metal. It will not get absorbed and heat up the metal like ultrasound does. You can safely treat over knee and hip replacements, metal plates and screws and even metal clips for someone whose had surgery.

Q: Will laser go through a cast?
A: No. The cast will completely block the laser light. Some creative doctors have cut small holes strategically placed in the cast so they can apply laser therapy to the fractured bone.

Q: Can we treat over kinesiotape?
A: You could, but the tape will block virtually all of the applied laser. And darker colored tape may get hot if you run the laser too long over it.

Q: Should we ice before or after K-Laser® Treatments?
A: Before. Ice will cause vasoconstriction, reducing the amount of blood in the superficial tissues and giving slightly better penetration of the laser into deep tissues. K-Laser® Treatments cause vasodilation, so icing afterwards would be counter-productive.
FREQUENTLY ASKED QUESTIONS

Q: What if a patient complains of post-treatment soreness?
A: This will happen rarely when treatments are properly delivered. The typical response is for the treated area to be sore 1-2 hours after the treatment, then later in the day or the next day the area will feel better. You could have the patient ice the area if it is sore. In extreme cases, an ointment containing benzocaine could be used. Be sure to reduce the wattage of the protocol by 30% on the next K-Laser® Treatment.

Q: Can we clean a wound with alcohol before applying K-Laser® Treatment?
A: Yes. It's a good idea to rinse with sterile water after cleaning with alcohol.

Q: Can we use products such as local antiseptics or Betadine before applying K-Laser® Therapy?
A: Yes, with care. You should definitely rinse any Betadine/iodine products as this can cause increased thermal sensitivity. Rinse any solutions that would leave a darker color.

Q: What if we hire a new employee six months from now, can they get trained?
A: Yes. You have access to the K-LaserUSA Online Resource Portal for all of your staff, regardless of size, and for as long as you own your K-Laser® Device. New hires in the future may view the modules, download the notes and take the certification exam, free of charge. Hands-on training at your clinic for future hires would depend on rep availability, and there may be a charge for that.

Q: What if we have forgotten our 'Username' and 'Password'?
A: That's OK. Go to the K-LaserUSA website (http://www.k-laserusa.com) and in the upper right corner, enter what you think is the username and password. If it works, OK. If not, on the next page there will be a link that says, "Lost your password?" You can use this to reset your password online. Or if you need more help, give us a call at 866-595-7749.
LASER HISTORY AND SCIENCE

Einstein first envisioned the concept of Laser radiation back in 1917. However it was not until 1960 that the first Laser was built by Theodore Maiman. It was another 25 years or so before technology advanced enough to make Lasers safer, easier to use, and cost effective. Dr. Endre Mester is credited with the discovery of the biostimulative properties of red and near-infrared light. He stumbled upon this serendipitously during an experiment designed to find out if Lasers might cause cancer. (They did not!)

LASER is an acronym that stands for Light Amplification by the Stimulated Emission of Radiation. Lasers differ from regular light, in a few very important ways. Laser light is a non-ionizing form of energy that is part of the electromagnetic spectrum. Electromagnetic energy travels in waves.

As opposed to ordinary light, laser light waves are in sync. The peaks and valleys are on top of each other, they reinforce each other and they help propagate each other. This is called coherence. Another difference from ordinary light is Laser light is not divergent. It is collimated as demonstrated by a laser pointer. Finally, a laser is monochromatic. It is one wavelength or color. It is this characteristic that is responsible for a laser’s specificity and selective effect on tissue.

All lasers work in a similar manner. The following is a very simplified explanation. A medium of some sort is composed of atoms capable of reaching a meta-stable or “excited” state. This medium is charged by an external energy source and this pumps the atoms to their excited state. When the atoms fall back to their stable state, they give off this energy in the form of a photon. These photons are contained within a resonating chamber with mirrors on either end.

As the number of atoms in the excited state increases, the chance of the photons emitted spontaneously hitting another atom in the excited state to “stimulate” release of a similar photon increases dramatically. The resonating chamber amplifies this stimulation exponentially until laser light is produced. This light is then directed externally and guided to the target tissue.

Of course, this all takes place at the speed of light or virtually instantaneously. The chemical medium will dictate the wavelength of light that is produced and the wavelength will dictate to what function this particular laser is best suited. We are going to discuss medical lasers only and therapy lasers specifically.

As stated earlier, laser light in the red and near-infrared range has biostimulatory properties. Roughly, this corresponds to wavelengths between 600nm and 1100nm. The shorter wavelengths are absorbed more superficially and therefore do not have the ability to penetrate as readily as the longer wavelengths. Therefore, the most important aspect for determining which laser will best suit your needs relates to the depth of the structures you are most concerned about treating.

There are also some subtle differences in biological effects from one wavelength to another. In general, you would want a laser that emits a beam with a shorter wavelength if your main clinical concern was superficial wounds (600nm-750nm). For musculoskeletal problems, a longer wavelength with better penetrating capabilities would be more beneficial (750nm-1000nm).
Having multiple wavelengths, as do the K-Laser® K-CUBE™ 3 and K-Laser® K-CUBE™ 4, will give you a wider range of treatment options with better clinical outcomes.

We have emphasized the importance of wavelength for proper clinical applications. The second most important parameter that will dictate how effective a laser will be is the power. The power is the rate at which the laser energy is being delivered and is measured in watts (W). There are four things that happen to the laser energy when it strikes tissue. Some energy will be reflected back. Some will penetrate all the way through without interacting with the cells. Some will be scattered.

Finally, only about 20%-40% actually gets absorbed by the tissue at the cellular level to have a biologic effect. The power multiplied by the time of delivery will dictate the total amount of energy that is delivered to the tissue. This will be the dosage and is measured in Joules (J). There is a certain amount of energy or dose that is needed to elicit a clinical response. This dosage must also be able to reach the target tissue. This aspect of penetration and dosage is an important concept which many texts fail to address when discussing proper laser treatment parameters.

The strong red and infrared wavelengths and adjustable power give you the versatility to treat a wide range of clinical conditions both superficial and deep. We will discuss how you adjust these parameters to treat specific conditions later.

One additional property that is related to power and must be kept in mind is the power density (W/cm²). The lens in the handpiece causes the laser light to diverge when leaving the handpiece. If the energy were focused into a very small spot size then the threshold for thermal damage of tissue could be reached. The therapeutic effects of laser on tissue are based on photochemical biostimulation.

The technology incorporated into the K-Laser® K-CUBE SERIES™ handpiece allows for safe, efficient, treatment with little risk of discomfort or injury to the patient. This also will be discussed thoroughly in the treatment guidelines.

There are two other parameters to keep in mind when treating patients. The first is what we call the time domain of the laser. This is related not only to hand-speed during laser application but also to the pulsing frequency or "strobe" effect of how the laser is emitted. Hand speed is of some importance in that a very rapid motion may not allow for efficient penetration. (Think of waving your finger through a candle.) A small amount of dwell time is required for adequate penetration.

A good hand speed is approximately an inch per second, which is demonstrated on the training DVD. The more important thing to keep in mind is the pulsing rate of delivery by the Laser. The frequency (Hz) rate with which the laser is being delivered will have differing physiologic effects on tissue. Lower frequencies and continuous wave, for example, is better for pain modulation while higher frequencies are more anti-inflammatory.

Keep in mind that the protocols already set-up in your K-Laser® Device simplify all these parameters in an easy to use "point-and-shoot" technique.
OPTIMIZING LASER PHOTOTHERAPY

Bryan J. Stephens, PhD

Therapeutic Laser Industry Overview

As has been the case with technology throughout history, this field was pioneered by engineers, not academics, and it's a good thing. After all, if we waited until we understood why something works before we used it, we would be in the stone-age, literally (people were eating vegetables before they knew why plants grew and warming their bodies with fire before they knew about combustion). This young field has therefore suffered from the zeal of its boosters; people had found a way to make money, and to their defense, improve patient quality of life, and so were much less interested in learning why this therapy worked. In this last decade, the research community has been catching up and we have ever-growing insight into the mechanisms of this highly successful field.

Differentiating What We "Know"

Because this field is so young, there are still huge gaps in our knowledge base, both in the physical properties of the individual lasers, as well as in the biological implications thereof. There is now, however, a well-established research community dedicated to the general study and optimization of the biological effects of laser phototherapy. Experimentation falls into two major categories: in vitro and in vivo studies, each of which is necessary, but extrapolating results from one to implications in the other is difficult and often misleading.

In Vitro Studies

Microscopic studies on laser interaction with biological material are invaluable. They give us the ability to precisely control the cellular environment and completely isolate a huge range of absorption mechanisms en route to a better understanding of not only the governing dynamics behind the macroscopic success of phototherapy, but also techniques to optimize its delivery and efficacy. Mountains of research have been done on individual bacteria and mammalian cells and on monolayers of such cells in petri dishes. From these, along with concurrent work on molecular biology, we have a very clear picture of where light is absorbed in cells and which processes these interactions catalyze.

There is an important caveat, however, which resonates throughout the entire biological community: the reaction of a macroscopic matrix of cells that form tissue is NOT the sum of the reactions of each of the individual cells. One of the great mysteries of biology involves the complexity of cell-cell signaling and the ubiquity of bystander effects. A prime example of this intrinsic communication is in radiation oncology where researchers have used X-ray needles (microscopically narrow beams of X-rays) to irradiate individual cells growing in a monolayer. Amazingly, cells far away from the irradiated region somehow received information from the irradiated cells and underwent apoptosis (programmed cell death) in a way that is characteristic of cells that absorbed the ionizing radiation (even though they didn’t). Accordingly, we have to narrow the scope of individual cell and single cell monolayer studies to the search for absorption sites and the cellular functions affected by these sites, and stay away from making broader tissue-scale generalizations.
OPTIMIZING LASER PHOTOTHERAPY

In Vivo Studies

Studies on human patients, and to a lesser extent laboratory animals, are often the most convincing to potential commercial users (i.e. chiropractors, podiatrists, veterinarians, dermatologists, etc.) of therapeutic lasers, and with good reason. Proven functionality on the proposed client base is a very marketable result. They are, by nature though, expensive and time consuming, and for that reason are usually biased to keep the number of possible outcomes narrow and manageable. Also, since they are typically carried out with commercial laser setups that require purchase, studies that compare multiple types (brands) of lasers to each other and to control groups are rare. Far more often, a study compares the effects of a single laser to a control group; the slightly more robust trials at least vary a parameter or two (e.g. power density, treatment length, pulse frequency, etc.).

Results from these types of studies yield conclusions that a particular treatment works, but not why or even if this particular treatment is most efficient. For example, a case study showing the elimination of a toe fungus with pictures before and after 6 weeks of therapy is encouraging in that it works, but does not tell you that the use of a different kind of laser could have provided the same results in 4 weeks.

Still, clinical trials are indeed necessary and continue to give important perspective into the macroscopic effects of phototherapy. The increasing popularity and success of this field is almost exclusively attributed to the number and breadth of clinical applications. To understand the mechanisms of action, though, we must combine our studies with a closer look into the cellular, and deeper still, molecular interactions of laser radiation with biological material. We can then use both micro- and macroscopic results to guide the search for the most efficient therapeutic techniques.

The Well-Oiled Human Machine

By far the most obvious and fortunate conclusion we have been able to extract from in vivo studies (not only with respect to laser phototherapy) is that our immune system is capable of handling an extraordinary range of pathologies. The time scale and degree to which our cells can react and combat these contaminants is the subject of much study, but it is clear both that lasers do stimulate the immune system and that the restoration of healthy function continues well after the initial irradiation. The amount of heating done during the minutes of laser irradiation is minuscule compared to the time it takes to relieve the body of disease or infection. This leads to one very important piece of information: the body does most of the work itself and so the target for an effective laser treatment is NOT the pathology itself, but rather to stimulate the appropriate cell compartments that lead to the body’s natural repair mechanisms. Basically, we want to stimulate the cell’s metabolism (i.e. its ability to use oxygen to create energy).

Bacteria, on the Other Hand

There are about 1000 different types of bacteria commonly present in the human body most of which reside either on the skin, or in the digestive tract. Of these, only about 10% are maintainable in cell culture and able to be studied. Some are beneficial (e.g. those that aid in digestion of food) others pathological. With this wide variety of species, never-mind their different
functions and chemical signatures, it is prohibitively difficult to target any individual candidate or even to make the generalization that these candidates are more abundant than any other with respect to a particular pathology. Instead we can capitalize on one common feature in most bacteria: they do not like oxygen. Most bacteria are anaerobes that proliferate and metabolize much better in the absence of oxygen. Fortunately, this is in direct contradiction with the way our cells flourish and so stimulating the oxygen intake and conversion process will simultaneously help our healthy cells and inhibit bacteria.

**Mechanisms**

**Identifying Targets**

The most fundamental thing to keep in mind is that the cell (and the body as a whole) is comprised of more than 80% water. The variation in water content between different kinds of cells (with the exception of bone cells) is negligible and so laser therapy as a whole is highly non-selective. Cells do, however, contain some heavier elements that can act as a contrast agent against water, and which can therefore be targeted with laser radiation; the most relevant examples are iron and copper. Not surprisingly, these elements are the ones that exist at the core of the two most important photoacceptors in the body: hemoglobin at the core of blood cells and cytochrome c oxidase in the mitochondria. By and large these complexes are the principle absorbers of mammalian tissue by light in the near infrared (NIR) range of the electromagnetic spectrum (other than melanin in the skin). As such, and before any attention to their function, the characterization of absorption of these complexes was of paramount importance, and the subject of much study. Action spectra (i.e. the dependence of wavelength on absorption) have been generated for these (and other) targets in vitro and the peaks have been isolated and correled with the biologically state of these complexes (see section "Clinical Functionality").

**Metabolic Action**

The action spectra tells us where in the spectrum and at what rate laser radiation is absorbed by these chromophores, but we must address the biology of the cell to understand the subsequent chain of events that lead to a beneficial, curative result. As discussed earlier, the central goal is to stimulate the cell (and ultimately, the body) to perform its natural functions, but at an enhanced rate. These natural functions are not only extremely numerous (ranging from protein synthesis to enzyme secretion, from cell signaling to physical movement) but also highly cell-type dependent. Any attempt to directly target one of the multitude and variety of these specific enzymes is difficult, and fundamentally unnecessary. If instead, the metabolism, specifically the respiratory chain, can be stimulated, the cell will enhance the functionality of all of its natural processes.

Fortunately, both hemoglobin and cytochrome c oxidase are involved in cell metabolism and their roles in the respiration chain are linked. Hemoglobin is the molecule, at the core of red blood cells, that transports oxygen through the body to the cells. When it reaches the cell it has to be de-oxygenated or "reduced". The oxygen is then passed through the cell membranes and into the mitochondria where it is processed by a series of enzymes, the last of which is cytochrome c oxidase. Here the oxygen is again "reduced" as it is converted into water; this reaction is the stimulus for the enzyme ATP synthase to create ATP, the source of chemical energy in
cells. This is the reason we need oxygen, slightly more in depth than "to breathe".

**Optimizing Efficiency**

Zooming out to the big picture, hemoglobin carries the oxygen through the blood from the lungs to the cells. It has to be reduced and the oxygen flows through the respiratory chain to the terminal enzyme, cytochrome c oxidase, which then reduces again to create energy for the cell. Think of the hemoglobin as the faucet that governs the rate at which oxygen flows into the cell and cytochrome c oxidase as the drain that determines the rate at which oxygen can exit the cell in the form of ATP (energy). To optimize efficiency of the flow of oxygen through the respiratory process, the most appropriate course of action would be to open both the faucet and drain as wide as possible (opening one without the other would not increase the overall throughput); that is, stimulate the amount of hemoglobin that reaches the cell, the rate at which it reduces its oxygen, and then the rate at which the cell can process that oxygen and output energy. The goal then is to increase local blood circulation, stimulate the reduction of hemoglobin, then stimulate both the reduction and immediate re-oxygenation of cytochrome c oxidase so the process can start again.

**Clinical Functionality**

**Circulation**

Recall the first goal of an effective therapy was to increase the amount of oxygen available for the cell to process. This means increasing blood circulation since the hemoglobin in red blood cells are the transporters of oxygen from the lungs to the cells. On the macroscopic scale, this relies on increasing the heart rate, which in turn slightly increases body (and blood) temperature. This is why exercise is good therapy for almost any ailment; increasing blood flow increases metabolism and stimulates the immune system. Locally around a wound, however, topographical heating does very little, resulting in neither an increase in circulation nor metabolism. This type of thermal effect is not the mechanism for laser stimulation of circulation. Laser irradiation instead creates local temperature gradients; that is, temperature differences on the molecular level that create potentials along which blood cells are more likely to flow. The stronger and more numerous the gradients, the more local circulation of oxygen can be stimulated.

What is the most efficient way to cause these temperature fluctuations? Recall that the cell is more than 80% water. If you can target the absorption of water by a particular wavelength of radiation, you can cause local resonances that reinforce themselves. In the entire NIR region (i.e. from 700-1000 nm) the strongest and most distinct peak in absorption is at 965 nm; the right side of Figure 1 shows the absorption spectrum of brain tissue in the NIR.

**Hemoglobin Deoxygenation**

Once the increased circulation gets the blood to the cell, the hemoglobin that carry the oxygen in the blood have to drop off their oxygen supply. Oxygenated and deoxygenated hemoglobin have very distinct signatures in the NIR. We are not concerned with the process of re-oxygenating the hemoglobin, because this occurs in the lungs. Instead we are interested in the absorption spectrum of oxygcnated hemoglobin (HbO2) whose deoxygenation can be stimulated by
the absorption of a photon of radiation. Figure 1 shows this rather broad peak that covers the higher end of the NIR.

**Figure 1:** Absorption spectra of cytochrome (left axis), oxygenated hemoglobin (a.u.), and brain tissue (right axis). Data re-digitized from [2].

**Cytochrome c Oxidase Redox**

As discussed earlier, the terminal enzyme in the respiratory chain of a cell, cytochrome c oxidase, is the principle absorber of radiation in the entire cell and governs the rate at which oxygen is processed into ATP. Unlike the one-way deoxygenation of hemoglobin, cytochrome receives and delivers its oxygen in cycles within the cell and so we need to stimulate both processes in order to maximize efficiency. It turns out that laser irradiation does both, depending on the oxidation state of the enzyme. When deoxygenated, laser irradiation will stimulate oxygenation, and vice versa [1]. This effect has resounding implications and is thought to be the universal validation of laser therapy. The different oxygenation states of this enzyme have peaks throughout the visible-NIR spectrum, which is why virtually all wavelengths used have shown to be useful.

Laser phototherapy with wavelengths throughout the NIR spectrum enhances cellular metabolism, but there exists a peak in the absorption spectrum that can maximize this effect. Figure 1 shows the difference spectrum in the absorption of oxygenated vs. deoxygenated cytochrome. Remember, when the enzyme is either fully oxygenated or fully deoxygenated, irradiation will push the cycle along in the right direction, so we want to stimulate the process at both endpoints. The peak in the difference spectrum reflects the wavelength at which laser irradiation will have the greatest effect to change the oxygenation state, which will subsequently turn the wheels of cellular metabolism most efficiently. This is analogous to firing the spark plugs at the exact time in the engine cycle to get the maximum effect.
Internal Dosimetry

Internal dosimetry of laser therapy is far too often overlooked or "guessed", but is crucial information for the design of treatment protocols and prediction of biological efficacy. In vitro studies have given us a general idea of the range of biostimulatory doses, but their results do not and should not be directly extrapolated to form conclusions in vivo.

It is universally understood, qualitatively, that the body is a turbid medium, which attenuates the penetration of radiation through a combination of absorption and scattering (reflection being scattering at angles greater than 90 degrees). But if laser therapy is ever going to be incorporated into mainstream medicine, there is a pressing need to be able to predict quantitatively the transmission losses and beam shape augmentation at depths through the variety of tissue types involved when treating the diverse spectrum of application of this modality. Here we employ some of these tools as we aim to bridge this gap and understand exactly how dose is distributed at depth in the body.

First-Order Approximation: Water Phantom

You can see from the full three-dimensional dose profile in Figure 2 that even in a simple water phantom at the most transparent wavelength (relative to the rest of the NIR) radiation intensity is strongly attenuated with depth. In fact, the red arrow shows that at depth of just 6 cm (just over 2 inches) the beam is down to 29% its original value. Also apparent is the amount of radial spread from the central axis due to the broad range of scattering angles. The anisotropy factor at this wavelength in water is about 0.8 which means that 80% of the scattering is directed in the forward hemisphere. This counteracts the absorption losses somewhat, but as you can see the attenuation is still quite steep.
Second-Order Approximation: MRI-Monte Carlo Simulation

Figure 3 shows the progression of stages in the simulation process. First, the anatomical positions of different tissue types need to be extrapolated from the MRI by a trained radiologist or surgeon. From there, the relevant literature was searched for optical properties of each tissue type at the given wavelength \[3,5,6,7\].

**Figure 3:** Stages of the Monte-Carlo Dosimetric Simulation. The different tissue types were identified as follows: A - muscle (subscapularis, teres major, latissimus dorsi, triceps) B - muscle (supraspinatus) C - bone (scapula) D - bone (humerus) E - tendon (of the supraspinatus) F - muscle and fat (omotransversarius) G - muscle (cleidobrachialis).

These parameters are overlaid on a contour map extracted from the MRI so that each voxel contains the absorption coefficient, scattering coefficient, anisotropy factor, and refractive index of the corresponding tissue type at the given wavelength. This particular simulation then initiated one billion photons each of which with the initial direction indicated by the red arrow and initial position distributed according to the measured 2-dimensional cross-sectional beam profile. The simulation then ran for fifty, 0.1 nanosecond time steps (remember radiation moves at the speed of light and so all the energy gets deposited very quickly) and recorded the absorbed dose in each voxel. Plotted are the values only in the plane of the MRI image, binned in 10% intervals, and normalized to 100% at the surface.

Third-Order Approximation: Ex vivo Measurement

Ex vivo measurement is the most accurate, humane form of internal dosimetry estimation. Six canine cadavers were used to perform a series of measurements, and as you can see from Figure 4, these measurements included several combinations of skin/hair, fat, muscle, tendons/ligaments, and bone to compile a full dosimetric profile. Also, several beam paths were evaluated to acquire optimal penetration angles. Let us give one full comparison of the three orders of estimation. Take example b) in Figure 4. The depth from the surface to the center of the joint where the detector was placed was measured (by digital caliper) to be 2.4 cm. From the curve in Figure 2, and assuming this dog to be a simple tank of water, we would predict the beam to transmit about 50% of its intensity to this depth. From an MRI-Monte Carlo simulation of this anatomical configuration, and including the estimated attenuation of skin, bone, fat, muscle, and joint tendons, we predict transmission of something more like only 5%. From the Si photodiode measurement, we find that only about 2% of the beam is transmitted to the center of the joint.
Figure 4: Radiograph Examples of Anatomical Orientation of Detectors in Cadavers. Notice the placement a) subcutaneously on the opposite side of the detector (measuring total transmission through the joint), b) in the middle of the joint (several beam directions were measured to acquire optimal penetration angles), and c) subcutaneously (to measure just skin/hair attenuation; several combinations of skin color, hair color, and coat length were evaluated).

Dosimetric Conclusions
As expected, the first-order experiments under-estimated the beam attenuation, but Monte Carlo results served as an accurate prediction of ex vivo observation. Dose delivered at therapeutic depths are up to 2 and 3 orders of magnitude less than those delivered to the surface. With enough data using a variety of skin, tissue, and bone thicknesses, this type of analysis will yield a full dosimetric profile.

An appropriate question is if ex vivo measurement of penetration and dose deposition is an accurate model of the in vivo situation. Preliminary measurements have shown good correlation between measurements of cadavers and living specimens. The simplest form of comparison is measurement through the entire leg of both a cadaver and a similar sized/colored dog. This data (not shown) is in good agreement, but the dose levels were quite low, and therefore the statistical significance of the data could be in question. More in depth studies on experimental animals will be needed to confirm this hypothesis, but such an experiment was beyond the scope and investment limit of the present study.

Much more work remains to be done in quantitative internal dosimetry of laser therapy. This study, however, is a necessary step in the right direction on the path of understanding the orders of magnitude involved. Once further enlightened, we will be able to review both existing and future studies to better understand the biological effect of the delivered dose that came from the reported treatment prescriptions, and eventually converge on the optimal treatment parameters for clinical success.

Take Home Message
FACT: Laser phototherapy, if administered by someone trained in the art, is beneficial in almost all of its forms and has no adverse side effects.

The differences between commercially available laser units lie solely in the wavelength, power density, frequency modulation, and aesthetics. From these parameters, you can derive the penetration depth, dose distribution, treatment time, and the estimated biological effect. There is NOT a "magic" wavelength or setting that is the cure for a disease, and to claim otherwise...
OPTIMIZING LASER PHOTOTHERAPY

(as many distributors or salesmen do) is irresponsible. There are, however, certain operating regimes that give better results than others and are more effective for particular symptoms. The select few modalities that have been specifically designed to isolate and capitalize on a fundamental therapeutic mechanism, have continually proved successful in the clinic. And since the primary mechanism of action is the stimulation of the body's natural anti-pathological immune system, the range of symptoms for which this treatment modality is useful knows no bound.

References


PHYSIOLOGICAL AND BIOLOGICAL EFFECTS OF LASER THERAPY

1. **Accelerated Tissue Repair and Cell Growth:** Photons of light from lasers penetrate deeply into tissue and accelerate cellular reproduction and growth. The laser light increases the energy available to the cell so that the cell can take on nutrients faster and get rid of waste products. As a result of exposure to laser light, the cells of tendons, ligaments, bone, nerves, and muscles are repaired faster.

2. **Faster Wound Healing:** Laser light stimulates fibroblast development (fibroblasts are the building blocks of collagen, which is predominant in wound healing) in damaged tissue. Collagen is the essential protein required to replace old tissue or to repair tissue injuries. As a result, laser therapy is effective on open wounds, scars, and burns.

3. **Reduced Fibrous Tissue Formation:** Laser therapy reduces the formation of scar tissue following tissue damage from cuts, scratches, burns or surgery by inducing production of more normal type-I collagen. Scar tissue is the primary source of chronic pain.

4. **Reducing Inflammation:** Laser light has an anti-inflammatory effect as it causes vasodilation, but also activates the lymphatic drainage system (drains swollen areas). As a result, there is a reduction in swelling caused by bruising or inflammation.

5. **Analgesia:** Laser therapy has a highly beneficial effect on nerve cells which block pain transmitted by these cells to the brain and which decreases nerve sensitivity. Also, due to less inflammation, there is less edema and less pain. Another pain blocking mechanism involves the production of high levels of pain killing chemicals such as endorphins and enkephalins from the brain and adrenal gland.

6. **Improved Vascular Activity:** Laser light will significantly increase the formation of new capillaries in damaged tissue that speeds up the healing process, closes wounds quickly and reduces scar tissue. Additional benefits include acceleration of angiogenesis, which causes temporary vasodilation, an increase in the diameter of blood vessels. More blood flow equals faster healing and less pain.

7. **Increased Metabolic Activity:** Laser therapy enhances enzymatic activity within the cell, facilitates oxygen delivery from the bloodstream into the respiratory chain, and increases cell membrane permeability. The damaged cells can repair and regenerate faster.

8. **Improved Nerve Function:** Slow recovery of nerve functions in damaged tissue can result in numbness and impaired limbs. Laser light will speed up the process of nerve cell reconnection and increase the amplitude of action potentials to optimize muscle action.

9. **Immunoregulation:** Photons are absorbed by chromophores (molecule enzymes) that react to laser light. The enzyme is activated and starts the production of ATP, which is the major carrier of cell energy and the energy source for all chemical healing reactions in the cells. Long lasting pain relief occurs.

10. **Trigger Points and Acupressure Points:** Laser therapy reduces muscle trigger points and stimulates acupuncture points on a non-invasive basis providing musculoskeletal pain relief.
TIPS TO IMPROVE K-LASER® TREATMENT RESULTS

Proper Diagnosis: In most cases, patients should exhibit a positive clinical response (i.e. decreased pain, increased range of motion) within four K-LEasar® Treatments. If not, re-assess your patient’s condition. Consider changes to the K-LEasar® Treatment regimen, or other changes in your care plan.

Line of Drive: Aim the laser with the line of drive to the intended target tissue. Make sure the wand is perpendicular to the skin and not treating at an angle. Holding the wand perpendicular decreases the amount of reflection and increases the amount of energy delivered into the tissue. If possible, maintain contact with the end of the treatment wand to the patient’s skin. This ensures a consistent output spot size, a consistent power density, helps separate hair, and gives more consistent clinical outcomes. If you cannot maintain contact (sensitive patient, broken skin), then do your best to maintain a consistent distance from the skin surface and hold the wand perpendicular to the skin surface.

Range of Motion during K-LEasar® Treatment: You can help the patient move the affected area through gentle active range of motion while you apply K-LEasar® Treatment. For example: While treating an arthritic hip, you or an assistant could grab the leg and gently move it through flexion and extension. This is a very effective way to stimulate mechanoreceptors in the stabilizer muscles and joint structures. Active ROM during K-LEasar® Treatment also helps break up adhesions in soft tissues. In very acute cases, you may want to assist the patient through passive ROM during K-LEasar® Treatment.

Treat from Proximal to Distal: Laser therapy stimulates blood and lymphatic vessels to dilate. If you treat distally first, fluids that are stimulated may have nowhere to escape if flow is blocked in the tissue above. This can lead to severe inflammation and pain. Always treat proximal to distal from the center of the body towards the periphery. For example: In swollen carpai cases, treat the axilla and descending lymphatics before treating the carpus and distal swelling.

Reduce Wattage: If you are too aggressive with the dosage on the first or second visit, the patient may experience increased pain and soreness. If increased pain is experienced repeatedly following treatments, it is recommended that the doctor reduce wattage by 30%. This will reduce the likelihood that a patient will drop out of care due to the continued discomfort. Also important to note is if no results are achieved in the first 3-5 visits, you would be likely to achieve better results by reducing wattage 30% rather than following the natural inclination to increase the wattage. If there is continued stagnation of the condition after utilizing this approach, it would then be advisable to start ramping up the wattage to higher than the preset range for several visits. If all of these variables yield no results, reassess the condition and make sure the causative agents fall in line with indications for K-LEasar® Treatment.

Pressure Technique: During individual point selection use the end of the treatment wand as an acupressure device when the laser is in Frequency Modulated (Hz) mode (not CW or ISP mode, due to risk of fur overheating). Don’t be afraid to push into the affected area, especially muscles. The added pressure pushes away the vascular beds, giving you a greater depth of penetration. You can do trigger point work with the K-LEasar® Device’s wand and the guiding hand. Pay attention to the power level and don’t leave it too long on one spot, or you risk discomfort for the patient.
TIPS TO IMPROVE K-LASER® TREATMENT RESULTS

Treat the Nerve Roots: For extremity cases, always treat the nerve roots that supply the area in question. Laser stimulation of the nerve roots will ‘energize’ those nerve roots, and most often leads to better pain management and injury healing. Apply the same treatment preset that you plan to use on the extremity, as well as the same guidelines for dosage. For example, if it is an acute extremity problem, put a lower dosage (about 200J and 4 J/cm²) into the nerve roots. Whereas if it is a chronic extremity problem, give a higher dosage (about 800J and 8 J/cm²) to the nerve roots.

Treatment Schedule: There is no "cookbook" for successful K-Laser® Treatments. In general, acute conditions should be treated with a lower dose and can be treated more often. Chronic conditions respond to a higher dose, but can be successfully treated only twice a week. Example - Acute sprained knee: use Frequency Modulated (Hz) mode only, dose about 2-4 J/cm², total dose around 200-400J, treat once a day for 4 days, then every other day for 3 days. Example – Chronic knee pain: use CW + Hz modes, dose about 6-8 J/cm², total dose around 600-800J, treat every other day for 3 treatments then twice weekly.

Metal Implants: It is safe to deliver K-Laser® Treatment directly over metal implants, whether they are knee or hip joint replacements, rods in the spine, or other metal implants. First, any heating of the skin during a K-Laser® Treatment is minimal. Second, the tissue components are absorbing the laser energy and heating. There is no heating of the metal in the implant. Patients with joint replacements are often in chronic pain due to the altered threshold of their pain fibers. K-Laser® Treatment can usually give these patients substantial pain relief.

K-Laser® Treatment before adjustment/manipulation/soft tissue: Using K-Laser® Treatment prior to manipulation and soft tissue work increases your success rate. Laser decreases the natural ‘splinting’ and ‘guarding’ associated with underlying stabilizer support muscles during injury. Your adjustment will be more effective, less painful for the patient, last longer and prevents the natural ‘rebounding muscle memory’ phenomenon. Patients will get better faster and require fewer visits to get the desired response.

Nutrition: Laser therapy enhances circulation and draws nutrition into the area. Patients with poor general nutritional status may not benefit as much from K-Laser® Treatments. Laser therapy is biostimulatory – it enhances the production of ATP from cells in affected tissues. One crucial nutrient for the production of ATP is Co-Enzyme Q10. This is especially true if the patient is also taking a statin drug for cholesterol reduction; statins deplete the body’s supply of CoQ10. If a patient is not responding to K-Laser® Treatments, consider supplementing the patient’s diet with at least 100mg CoQ10.

Geriatric Patients: Keep in mind that some geriatric patients may have increased sensitivity to K-Laser® Treatments, and may have reduced temperature sensation. Give geriatric patients a lower dose on the first visit than you would with a younger patient. Monitor them on subsequent visits — if they are experiencing no change or an exacerbation of symptoms, reduce wattage by 30% over the next 3-5 visits. At this point, if still not experiencing any progress it would be practical to begin incrementally increasing the wattage over the next several visits. Use the "trailing finger technique" to assess skin temperature during the treatment.
There are three basic ways to deliver the K-Laser® Treatment: scanning (in contact), pushing (in contact), and non-contact modes. This section will discuss these three delivery methods.

**Scanning Technique** means that you are moving the wand at a constant speed, sweeping it over the treatment area in a grid-like pattern. When doing this, you are painting the treatment area, giving it a saturating dosage of laser energy. Scanning is used when the K-Laser® Device is producing continuous wave laser and Intense SuperPulse modes, but you can also scan when in Frequency Modulated (Hz) mode. When scanning, be sure to cover the entire area and do not focus on just one tiny spot. Scan the treatment area in a back and forth, up and down motion to make sure that all tissues are receiving beneficial K-Laser® Treatment energy.

All conditions benefit from treating the surrounding healthy tissues, through vasodilation, improved vascular activity, biostimulation, and release of endogenous hormones. Healthy tissues can absorb a great deal of laser energy without any deleterious effect.

**'Pushing'** or **'Pressing'** is normally done when the K-Laser® Device is in the Frequency Modulated (Hz) mode. You can pause and hold the K-Laser® Treatment wand in one place for a few seconds, if clinically indicated. You can also use the treatment wand as a pressure device to work on trigger points, giving the combined benefit of pressure with K-Laser® Treatment energy.

**'Non-Contact'** mode is particularly useful when there is an open wound or sensitive skin. If you come off the surface, but fine-tune the beam to be the same size as it was when you were in contact, the treatment is identical. This is the huge advantage of our Adjustable Zoom Handpiece.

In all modes, be sure to hold the treatment wand perpendicular to the surface you are treating. This minimizes reflection from the skin surface and ensures the maximum penetration of beneficial K-Laser® Treatment energy.
LASER EYE SAFETY
FOR CLASS IV THERAPY LASERS

Class IV therapy lasers are being used by a growing number of medical practitioners including chiropractors, physical therapists, athletic trainers, rehabilitation specialists, osteopaths and medical doctors. High-powered therapy lasers have the ability to deliver a therapeutic dosage in less time, but the potential risk for injury is greater. The following are guidelines for laser eye safety in the use of Class IV therapy lasers.

All therapy procedures carry with them an element of risk, either through carelessness or by accident. Periosteal burns and cavitation are possible with ultrasound and surface burns can result from improperly used hot packs or electric muscle stimulation. Safety procedures should be in place for all therapies used in a chiropractic office.

Laser safety guidelines must be followed primarily due to the risk of eye injury. Direct exposure or reflected laser light can be focused by the lens, causing damage to the retina and resulting in scotoma, a blind spot in the fovea. Light incident on the eye is magnified more than 100,000 times by the lens.

Figure 1: Visible light ranges from 400-700 nanometers (nm)

Ultraviolet wavelengths are shorter than 400 nm, and infrared wavelengths are longer than 700 nm. Visible light has wavelengths between 400 and 700 nm (Figure 1), and therapy lasers use wavelengths between 635 and 980 nm. Class IV therapy lasers use wavelengths in the near infrared, so they are invisible to the human eye but can be visualized using a digital camera (Figure 2). Wavelengths from 400 to 1,400 nm are focused by the cornea and lens and absorbed by the retina.

Figure 2: Class IV lasers use infrared wavelengths, which are invisible, but can be photographed with a digital camera.

Power is the rate of energy delivery and is measured in watts, equivalent to a joule per second. Class IV lasers have power output greater than 500 milliwatts (mw), and the highest-powered FDA-cleared therapy laser has a maximum power of 15 watts (15,000 mw). Just as with household light bulbs, a higher wattage indicates brighter light.
LASER EYE SAFETY
FOR CLASS IV THERAPY LASERS

The blink reflex is "lid closure associated with the involuntary upward movement of the eye, triggered by an external event" such as a bright flash of light. The aversion response is "movement of the eye, eyelid, or the head to avoid an exposure to a bright light" and can occur in one-fourth of a second, which includes the blink reflex time. Since Class IV therapy lasers use invisible infrared wavelengths, they do not trigger the blink reflex or aversion response. This is a crucial point to emphasize with those new to high-powered therapy lasers.

The maximum permissible exposure (MPE) is "the level of laser radiation to which a person may be exposed without hazardous effects ... in the eye or skin." In the MPE calculation, the worst-case scenario is assumed, in which the eye lens focuses the light into the smallest possible spot size on the retina for the particular wavelength and the pupil is fully open. Exposure to direct or reflected laser light above the MPE can result in injury.

The nominal hazard zone (NHZ) is "the space within which the level of the direct, reflected or scattered radiation during normal operation exceeds the applicable MPE." The NHZ for most Class IV therapy lasers is 21 feet. This means that all people within a radius of 21 feet must be wearing appropriate eye protection when the laser is in operation.

Eye protection must be supplied by the laser company. Normal sunglasses do not provide adequate protection. Laser safety eyewear is marked with the optical density (OD); a measure of the ability to block out specific wavelengths of laser light to a safe level below the MPE. Laser manufacturers and distributors should provide information on the MPE, NHZ and OD in the safety manual supplied with the laser equipment.

The beam from a surgical laser is tightly collimated, whereas the beam from a high-powered therapy laser is divergent. Class IV therapy lasers use diodes as the lasing material, which consists of at least two layers of a semiconductor material sandwiched together. Unlike other types of lasers (gas, solid, metal vapor or dye), diode lasers have beams with a large divergence.

Figure 3: Conditions of ocular exposure to direct or reflected laser beams

A. Intrabeam viewing of collimated laser
B. Mirrored reflection of collimated laser
C. Mirrored reflection of collimated laser
LASER EYE SAFETY
FOR CLASS IV THERAPY LASERS

When a collimated beam bounces off a highly reflective surface (Figure 3b), the reflected beam maintains a high energy density and the possibility to cause eye damage is very high. The beam from a high-powered therapy laser is normally reflecting off a rough surface of the skin (Figure 3c), so the reflected beams have a much lower energy density and carry a significantly reduced risk of eye injury. The mirrored reflection of a collimated laser can cause immediate blindness, whereas the diffuse reflection of a therapy laser is comparable to looking at the sun through a layer of thin clouds (Figure 2).

To summarize, an increasing number of medical professionals are discovering Class IV therapy lasers to be an effective modality for pain management and injury healing. They have the ability to deliver a therapeutic dosage in less time, but also carry an increased risk of eye injury and must be used in a closed room with everyone wearing laser-specific eye protection.

For a more detailed coverage of laser safety, including a list of contra-indications and occupational safety protocols, refer to the K-Laser® Device’s Operator’s Manual and Safety Manual provided with the purchase of your K-Laser® Device.

References
2. Ibid.
3. Ibid.
4. Ibid.
5. Ibid.
CALCULATING THE ENERGY DENSITY OF A THERAPY LASER

Before performing any calculations of energy density, be sure that all quantities are expressed in their proper units; i.e., convert time in minutes to time in seconds. The power of a therapy laser is measured in watts, and one milliwatt is one-thousandth of a watt: 1 mW = 0.001 W. Lasers used by chiropractors range in power from 5 mW up to 10 W. Convert the milliwatts to watts before doing any calculation (i.e., 5 mW = 0.005 W). You can think of the power of a laser just like the brightness of a light bulb: the higher the wattage, the brighter the laser light. Power is the time rate of delivery of energy, and the three are related by the following equation:

\[ \text{Power} = \text{Energy} / \text{Time} \]

Therefore, you can calculate the energy delivered by a therapy laser by multiplying the power times the time. For example, the energy delivered by a 100 mW laser in three minutes would be (converting the 100 mW to 0.1 W and the three minutes to 180 seconds):

\[ \text{Energy} = \text{Power} \times \text{Time} = 0.1 \text{W} \times 180 \text{s} = 18 \text{ J} \]

To calculate the energy density, simply divide the energy in joules by the area in square centimeters as follows:

\[ \text{Energy Density} = \frac{\text{Energy}}{\text{Area}} \]

For example, let’s say the 18 J from the previous calculation is delivered to three different areas: 100 cm² (the area of a man’s palm), 5.5 cm² (the area of a postage stamp) and 0.4 cm² (the area of a pencil eraser). As you can see from the chart [at right], 18 J of energy can produce widely varying amounts of energy density, depending on the size of the area being treated.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Unit of Measurement (Abbreviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>Watts (W)</td>
</tr>
<tr>
<td>Area</td>
<td>Square Centimeters (cm²)</td>
</tr>
<tr>
<td>Energy</td>
<td>Joules (J)</td>
</tr>
<tr>
<td><strong>Energy Density</strong></td>
<td>Joules per Square Centimeter (J/cm²)</td>
</tr>
</tbody>
</table>

If the laser probe is held in one spot during treatment, you will need to determine the area of the laser-output spot size. When treating a larger area, you will need to measure and calculate the area in square centimeters. One way to estimate the area is to measure the area of your palm and count the number of “palms” treated on the patient. Then multiply this number by the area of your palm.

Energy density can also be called treatment dose or fluence. I prefer the term energy density to make sure it is distinct from simply “energy.” Energy measures the ability to do work, whereas energy density measures the concentration of that energy over a specific area. As the chart above shows, an amount of energy can produce significantly different values of energy density. The two are not equivalent.
CALCULATING THE ENERGY DENSITY OF A THERAPY LASER

<table>
<thead>
<tr>
<th>Area</th>
<th>Energy</th>
<th>Energy Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 cm²</td>
<td>18 J</td>
<td>0.18 J/cm²</td>
</tr>
<tr>
<td>5.5 cm²</td>
<td>18 J</td>
<td>3.3 J/cm²</td>
</tr>
<tr>
<td>0.4 cm²</td>
<td>18 J</td>
<td>45 J/cm²</td>
</tr>
</tbody>
</table>

If the energy density is too low, it will not biostimulate tissue, but if it is too high it will inhibit healing or even cause damage. An analogy: If you spread a gallon of water over an entire parched football field, you would have very few blades of green grass, and if you dumped that entire gallon onto a very small spot, you would have mud. The key to watering grass is getting the right amount of water per unit area, and the key to laser therapy is delivering the proper amount of laser energy per unit area.

What is the right amount? "Biostimulation has been reported in the literature with doses from as low as 0.001 J/cm² to 10 J/cm² and more. There is a great difference between irradiating naked cells in the laboratory and treating a deep-lying pain condition. In fact, a 'dose' is a very complicated issue. It is a matter of wavelength, power density, type of tissue, condition of the tissue, chronic or acute problem, pigmentation, treatment technique and so forth. However, there is certainly a 'therapeutic dose window.'"2 In their text, Tuner and Hode suggest an energy density of 2-4 J/cm² for superficial pain and 4-10 J/cm² for deep-lying pain.3

The primary goal of this article is to help you calculate the energy density of a therapy laser.

References

2. Ibid, p. 72.
3. Ibid, p. 73.
The palm of the average sized hand is about 100 square centimeters. Measure yours, and remember where the 100 cm² area compares to the actual size of your palm.

For a surface wound, biostimulation occurs when 0.5-1 J/cm² is delivered to tissue. For our example, let’s use 1 J/cm².

Most laser therapy experts agree that pain control requires 4-10 J/cm², we can use 5 J/cm² for our example.

A superficial wound about 6 cm in diameter will require treating a total area of 100 cm² to include a small amount of healthy surrounding tissue.

Most K-Laser® Device wound protocols are programmed to deliver 2 watts with variable frequencies to stimulate a proper tissue response. (Average 1 watt) This delivers 1 Joule/second. We would need about 100 seconds to treat this area if it were a single cell layer.

Wounds are multiple cell layers thick. Therefore, we usually would double the dose and treatment time for a wound of this size. For example, you would treat this wound for at least 2 to 4 minutes. You can extrapolate this same dose by imagining how many "palms" large each wound is.

This same calculation works for deeper pain management. Let’s say you are working on the lumbar spine, treating an area two palms large. You would need 200 cm² X 5 Joules/cm², or 1000 Joules. In this case we recall that about half of the energy delivered penetrates below the dermis - we should multiply the dose by 2 to account for this. We would want to deliver about 2000 Joules to the area for deep pain control.
Delivering the appropriate dosage to the target tissues is a key to success with K-Laser® Treatments. As indicated in previous sections, laser therapy dosage is measured in Joules per square centimeter, J/cm². It is a measure of the amount of energy per unit area that is being administered by the K-Laser® Device.

A dosage too low will have no effect, while too much dosage will inhibit healing and may exacerbate the patient’s condition. It should also be noted that healthy cells and tissues can be treated with almost any dosage of laser therapy without noticeable negative effects. Injured and damaged cells absorb laser photons much more readily than healthy cells.

This does not mean that you should “blast away" with the highest wattage possible for all conditions. Use the preset protocols as well as the dosage suggestions so you can deliver the most effective K-Laser® Treatments to your patients. The chart below is a guideline for appropriate dosage for K-Laser® Treatments.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Dosage, J/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial wound</td>
<td>1-2</td>
</tr>
<tr>
<td>Superficial pain</td>
<td>2-4</td>
</tr>
<tr>
<td>Acute deep pain</td>
<td>4-6</td>
</tr>
<tr>
<td>Chronic deep pain</td>
<td>6-10</td>
</tr>
</tbody>
</table>

This chart is a guideline for dosage. With laser therapy, the practitioner has some leeway in the dosage they can deliver and still have an effective outcome. Doses with laser therapy do not have to be as exact as they do for prescription drugs. A dosage of 4.2 J/cm² may produce a very similar effect in a patient that a dosage of 6.7 J/cm² would. (The point is — you would not give this patient a dose of 0.3 J/cm², or 30 J/cm². Keep it in the ballpark of recommended dosages for best results.)

You could measure the area you are treating, but this would create an unnecessary slow-down in your treatment delivery. Estimating the area will be sufficient — the area of an apple cut in half is about 50cm², or the area of the palm is roughly 100cm² (measure yours to be sure.) Then you could estimate the number of apple- or palm-sized areas you are treating.

As a beginner, do your best to achieve the target dosages listed in the table, and with clinical and treatment experience you will gain knowledge and skills to deliver dosages appropriate to the patient’s condition. A few examples of dosages follow:
DOSAGE DISCUSSION AND EXAMPLES

Example: Right-Sided Cervical Pain
The treatment area extends from sub-occipitals down to T2, extends laterally to the insertion of the trapezius, and anteriorly to include the scalene. The size of the treatment area will depend on the size of the patient, and will be in the range of 150-250 cm². Let’s use 200 cm². If the condition is chronic deep pain, you would want about 6 J/cm², which would mean a total dosage of 200 cm² X 6 J/cm², or 1200J.

Example: Lumbar Disc Herniation with Radicular Pain
In this example, the patient is suffering from a lumbar disc herniation accompanied by radicular pain into the right gluteal region. The estimated treatment area would be 300-500cm², and the dosage should be around 8 J/cm². This calculates to 2400 to 4000 J total dosage for this treatment.

Example: Wrist Pain Treatment
The treatment area shown in the picture is about 70-100cm². If the K-Laser® Treatment was for acute pain, the recommended dosage would be about 3 J/cm², giving a total dosage in the range of 200-300J.
DOSAGE DISCUSSION AND EXAMPLES

Acute conditions should be treated with a slightly lower dosage, and can be treated more often. For example, an acute sprained ankle could be treated once a day for 5 days — but the dosage with each treatment should be at the low end of the recommendations, about 2 J/cm².

Chronic conditions can be treated with a higher dosage, with more time in between visits. For example, a patient with chronic low back pain could be given a dosage of 10 J/cm², and a relatively high total dosage of roughly 5000 J, but they would only need to be seen once or twice a week.
FREQUENCY MODULATION DISCUSSION

When speaking of clinical efficacy, dose is not the end of the story; there is another very important treatment parameter. The way that dose is delivered greatly influences the clinical results. There are two main delivery modes for laser therapy: Continuous Wave (CW) and Pulsing (which can then be subdivided into Frequency Modulated and SuperPulsed).

Your K-Laser® Device has the capability to deliver therapeutic laser energy in all three modes. This section will discuss the benefits and indications for various frequencies of light.

One thing we know very well as an industry is that the responses of different tissue-types vary widely within a large range of pulse frequencies.

When the K-Laser® Device is operating in pulsed mode, it is operating with a 50% duty cycle. This means the laser light is 'On' half the time and 'Off' half the time. The pulse rate can be varied from 2 to 20,000Hz. When operating in pulsed mode, the average power output is one-half the peak power. For example, if the K-Laser® Device was set at 6W, the average power output in pulsed mode would be 3W.

The figure depicts two different laser pulse frequencies. The top indicates continuous wave, the next pulsed with a 50% duty cycle, the next pulsing at a faster rate, and the bottom Intense SuperPulsed.

Continuous Wave (CW), Frequency Modulated, or SuperPulse

A meta-review of the literature from 1970-2010 regarding the effects of pulsing in laser therapy made two conclusions: 1) that different tissues respond better to different frequencies, and 2) we have yet to determine why and which ones are the best, but that there is no "one size fits all" frequency that is optimal for all conditions.
FREQUENCY MODULATION DISCUSSION

These are very simple experiments to carry out... you take several different tissue types and expose each to exactly the same dose, but in each case, using a different frequency. Continuous Wave would be a frequency of 0 Hz; the beam is always on. Then when you measure the cellular activity, whether it is by ATP synthesis, DNA proliferation rate, enzyme regulation you'll find that the different tissue-types respond to different frequencies.

The direct mechanisms are unclear, but a good first-order explanation is that is has to do with the different thermal dissipation characteristics. Cells are small enough to dissipate heat on the order of micro- or milli-seconds, which can be between pulses of laser. Each cell type has different water content; osteoblasts are about 60% water whereas smooth muscles cells are closer to 90% water. Water is a very good conductor of heat and so the higher the water content, the quicker that cell can dissipate its heat.

This could be why bones seem to respond better to lower frequency, while soft tissue heals faster with higher frequency. This also coincides with Tiina Karu's conclusions that show the most important pulsing parameter to be the “dead-time” between pulses. She showed, on the same cell line, a distinct difference between pulse widths of 2 milliseconds (which corresponds to 500 Hz) and 100 micro-seconds (which corresponds to 10,000 Hz).


For any particular condition, there are several tissue types present, and each type does very different things when it metabolizes. Take, for example, a shoulder. There is bone, cartilage, connective tissue, muscles, blood vessels, and more involved in that ailment and so to choose...
FREQUENCY MODULATION DISCUSSION

one parameter set (i.e. wavelength/power/frequency combination) to treat the entire ailment for, say, 5 minutes, is not the most efficient technique. If instead you progressed through several combinations within a single treatment protocol (as does every pre-set protocol in the K-Laser® Device), you have a better chance of individually stimulating each tissue type, thus healing the condition quicker.

So it is important to have the ability not only to deliver both Continuous and Frequency Modulated light, but also to offer a full spectrum of frequencies to be able to efficiently target the many types of tissues in the body.

As stated, various pulse rates elicit a different response from the tissue. The research in this field has not yet made clear exactly which frequencies are particularly suited to which treatments, however there is a supportive body of empirical evidence. The table below gives the frequencies that are considered suitable for certain types of problems.

<table>
<thead>
<tr>
<th>Indication</th>
<th>Pulse Frequency, Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone, Cartilage</td>
<td>CW; 2-100</td>
</tr>
<tr>
<td>Connective Tissue</td>
<td>500-700</td>
</tr>
<tr>
<td>Soft Tissue (Muscle)</td>
<td>2500-5000</td>
</tr>
<tr>
<td>Open Wounds</td>
<td>10,000</td>
</tr>
</tbody>
</table>

When treating a patient, the pulse frequency should be varied to deliver several different frequencies and thus several different benefits. Also, the body has a tendency to adjust to any outside stimulus, so varying the pulse frequency during the K-Laser® Treatment will produce better results.

For beginner users, we suggest sticking with the K-Laser® Device's preset protocols. The pulse frequencies that will be most beneficial for each specific condition have already been built into the K-Laser® Device. Having a general knowledge of the various effects of different pulse frequencies will make you a more educated provider, and once you have achieved a level of proficiency, you may choose to set your own pulse frequencies.
INTENSE SUPERPULSE DISCUSSION

Your K-Laser® Device has the capability to deliver therapeutic laser energy in three modes: continuous wave, pulsed, and Intense SuperPulsed (ISP). This section will discuss the benefits and indications for various frequencies of ISP mode.

As noted in a previous section when your K-Laser® Device is operating in the normal pulsed mode it is at a 50% duty cycle, with the laser light being ‘on’ half the time and ‘off’ half the time. In ISP mode, the K-Laser® Device is producing a very bright light for a very short period of time.

The peak power of each pulse is 10W for the K-Laser® K-CUBE™ 2, 15W for the K-Laser® K-CUBE™ 3 and 20W for the K-Laser® K-CUBE™ 4. The average power is indicated on the display as Average Power. The ISP average power maximum is 6W for the K-Laser® K-CUBE™ 2, 8W for the K-Laser® K-CUBE™ 3 and 12W for the K-Laser® K-CUBE™ 4. The ISP pulse frequency can be set form 1 to 20,000Hz for each model.

If the average power is reduced, the peak power will stay the same, but the pulse widths will be automatically adjusted (that is, the Duty Cycle will be adjusted) to deliver your entered Average Power with your selected pulse frequency. For example, with the K-Laser® K-CUBE™ 3 in ISP mode, the peak power is always 15 Watts, regardless of the average power or pulse frequency selected.

Let us assume you set the pulse frequency to 100 Hz. If the average power is set to 3 Watts, the Duty Cycle will be automatically changed to 20% (20% of 15 Watts is 3 Watts). If instead you select an average power of 6 Watts, the Duty Cycle will be set to 40%. In both cases, since the pulse frequency is set to 100 Hz, the beam will flash on and off 100 times per second at identical intervals. However, when the average power is set to 3 Watts, the pulse width (length of time of those flashes) is shorter than the same 100 Hz setting at an average power of 6 Watts.

ISP mode has the advantage of driving laser energy deeper into the tissues, without heating the superficial tissues as much. An easy demonstration you can do yourself is to run the K-Laser® Device at 6W continuous wave on your forearm, then run ISP mode set at 6W average power. The K-Laser® Device is producing an average power output of 6W in both cases, but you should notice that the ISP mode does not heat your skin as quickly.

ISP has three distinct advantages over continuous wave and regular pulsing: when targeting deeper conditions; when treating patients with a dark skin type; and as a different mode of laser delivery. The body absorbs radiation exponentially and so the surface is exposed to the most dose. The main limitation of delivering a lot of dose to deeper structures is the buildup of heat at the surface. ISP mode allows the delivery of higher doses with the advantage of allowing thermal relaxation time between these pulses. In this way, you can reach deeper tissues (which require higher doses at the surface) without the thermal accumulation at the surface.

As you can see by the diagram below, the ISP mode can deliver laser energy deeper. So if the target is a lumbar disc, hip joint, or some other deep target, the patient may benefit from ISP mode.

Melanin absorbs laser energy, and the darker the skin type, the more melanin there is at the surface. Continuous wave laser will heat dark skin very quickly, and much of the therapeutic
benefit is lost. ISP will drive more laser energy deeper, while still allowing heat to dissipate between pulses, resulting in less warming of the skin.

One fact of life about any treatment modality is that the body is very quick to adapt. Whether you administer medication, massage, exercise, or nutrition, variety is necessary to avoid diminishing returns. ISP mode offers yet another delivery mode to "trick" the body out of its natural tendency to become "immune" to any treatment.
WAVELENGTH AND TISSUE PENETRATION

Wavelength of light is a measure of the distance between successive points on the light wave, and is typically expressed in nanometers. The color of light is determined by its wavelength, i.e. blue ranges from 450-475nm, green from 495-570nm and red from 620-750nm. There is an "optical window" around 700-1100nm where the absorption by the body is lowest, which means the laser energy will penetrate the deepest. The central valley of this window (i.e. the deepest penetration wavelength) lies around 800nm.

The K-Laser® K-CUBE™ 4 produces four therapeutic beams: the visible red beam is 660nm, the infrared beams are 800, 905, and 970nm. The infrared region of the spectrum is invisible to the human eye.

Wavelength is the primary determinant of tissue penetration for a therapy laser. Three components in tissue will absorb photons more than the rest: water, melanin and hemoglobin. As you can see by the figure 1, these three components have a slightly different absorption curve.

![Absorption spectra of the body's four principal chromophores.](image)

**Figure 1:** Absorption spectra of the body's four principal chromophores.

The goal with a therapeutic laser is to drive laser energy deep into the tissues to biostimulate the deep tissues and enhance the repair and regeneration processes. Red wavelengths of light are absorbed by the hemoglobin and melanin and get absorbed in the superficial tissues. Red lasers, including the K-Laser® K-CUBE SERIES™ 660nm can be effective for surface conditions, may be effective for surface conditions, but are very ineffective for deep-seated conditions.

The K-Laser® K-CUBE™ 4 can deliver 4 treatment beams simultaneously: 660, 800, 905, and 970nm. Recall from the "Optimizing Laser Phototherapy" article on pg. 30, that the 3 primary targets in the photobiomodulation process are cytochrome c oxidase, oxygenated hemoglobin, and water. Notice that the K-Laser® K-CUBE™ 4 delivers a wavelength of treatment radiation that lies at the peak of each of these chromophores. To this end, the K-Laser® K-CUBE SERIES™ is the most efficient laser available to target the body's natural healing process. Also notice that since there is a high melanin concentration in the skin, and at 660nm melanin absorbs very well, our red beam will be ideal in targeting superficial dermatological issues.
The K-Laser® K-CUBE SERIES™ is the first patent pending therapy laser to incorporate up to FOUR independently regulated diodes optimally targeting the body’s natural light-absorbing complexes.

Blood is the primary transport system that brings oxygen to the cells and waste products away. Water in our blood absorbs very well at 970nm and when it absorbs a photon, all of the energy gets converted to heat. These deep, localized hot-spots create temperature gradients at the cellular level that stimulate local micro-circulation and bring more oxygen-fuel to the cells.

Oxygen is released at varying rates from the bloodstream, and the quicker this happens, the more fuel the cell has to carry out all of its natural healing processes. The peak of hemoglobin’s absorption lies at 905nm, and when this radiation is absorbed, more of this oxygen-fuel is made available to the cells.

The terminal enzyme in the respiratory chain is cytochrome c oxidase, which determines how efficiently the cell converts molecular oxygen into ATP. This enzyme’s highest absorption is at 800nm, cycling back and forth between reduced and oxidized states at its own pace, each cycle producing a molecule of ATP. Regardless of the enzyme molecule’s state, when it absorbs a photon it will flip states. Photon absorption will accelerate this process, and increase cellular ATP production.

Irradiating an area with 660nm, a wavelength where melanin in our skin absorbs very well, will ensure a large dose to the superficial region. Since light can both inhibit bacteria and promote cell growth, laser therapy has incredible results in wound healing and scar tissue regulation.
TREATMENT PLAN FORMULATION

Inside the K-Laser® K-CUBE SERIES™ lasers, you will find that chronicity and pain levels of the patient (combined with anatomy, skin type, and body type) are taken into account on the way to selecting the most appropriate treatment protocol for the patient and his/her condition. We have combined everything we know about laser therapy with everything you know about your patient and his/her condition and seamlessly organized the huge variety of power, frequency, wavelength, and treatment time options to fit the exact clinical scenario.

In this respect, the K-Laser® K-CUBE SERIES™ is an easy-to-use, point-and-shoot device. There are of course a number of variables that have not been considered, including (but not limited to) nutrition, exercise, range of motion, and lifestyle. While these variables would not change the protocol parameters or dose prescription of any single treatment, they are important factors in deciding the most important treatment schedule, as well as the most useful modifications to such a schedule if a patient is quicker or slower to respond to K-Laser® Therapy.

In the Atlas of K-Laser® Treatments, you will find a more specific treatment frequency recommendation for the wide variety of anatomies and conditions listed, but the following is a more general discussion to answer the questions, "how often should I treat?" and "how long will the effects last?".

Studies have shown that acute injuries respond better to a higher degree of fractionation; that is, more frequent treatments applying less dose per treatment. In these cases, local blood vessels have been more recently ruptured, and the injured cells have been more abruptly exposed to the immune system's regulatory enzymes. This system is already in the early stages of recovery, but K-Laser® Therapy's introduction of more energy to these cells will stimulate this process even further.

Acute injuries, especially after K-Laser® Therapy, tend to heal in a short recovery period, regardless of the tissue make-up (bone and soft tissue each heal quite quickly in the right, oxygen-rich environment). This is why we suggest prescriptions of three treatments per week until the condition resolves itself (usually in two weeks). To this end, the effects of K-Laser® Therapy can be thought of as permanent inasmuch as once the laser has aided in healing the injury, that injury has been healed indefinitely, and often with stronger tensile strength than the pre-injured state.

NOTE: In general, there is no such thing as over-dosing (not to be confused with over-heating, which is a necessary precaution that is discussed more in the Intense SuperPulse section of this book). The body has several ways of storing an excess production of ATP (useable reserves can last from minutes to several days) and so there is simply a saturation effect from treating too frequently; you will not receive any further benefit from treating twice a day than you would from treating once a day.

In chronic cases, however, cells have been injured for longer and blood supply to the affected area has deteriorated. In these cases more dose is necessary to "jump start" the system; that is to stimulate angiogenesis that brings fresh, oxygen-rich blood to the area and forces those injured (and often dormant) cells to metabolize once again. We often suggest 3-2-1 prescription: three treatments the first week, two the second, and one the third week, with mainte-
nance (booster) treatments as needed depending on the nutrition, activity, and progress of the injury.

The duration of effects of K-Laser® Therapy on chronic issues depends on every possible variable mentioned so far, and so we have listed a more specific “What to Expect” section under each anatomy in the Atlas of K-Laser® Treatments. Often, though, the aforementioned maintenance packages turn into preventative medicine, especially in the treatment of joints.

In either case, the outcome of each treatment session and the patient’s overall progress should be continuously monitored and the treatment plan adjusted accordingly.
DYNAMICALLY REFINED THERAPY (DRT)

At K-LaserUSA, we don’t guess. We calculate. We know that different tissue-types respond better to different treatment parameters. From thorough literature reviews and extensive original research, we have grown to learn a great deal about...

- How much dose is delivered to different anatomical depths
- What the laser does once it gets there
- What type of delivery modes are appropriate for which tissues

**Body Type & Anatomy**

One size does NOT fit all. We have taken everything we know about the makeup of each anatomical part and modified the settings to target just the right amount of bone, soft tissue, and fat for the individual patient.

The K-Laser™ K-CUBE SERIES™ combines everything we have learned about laser therapy with everything you know about your patient’s condition.

**Chronicity / Pain Matrix**

Different pain and chronicity levels require different treatment prescriptions. We have given you the ability to tailor each treatment to the specific needs of your patient.

**Multi-Frequency Protocols**

The K-CUBE™ treats with up to 12 sub-phases in each pre-set protocol, each using a different parameter set to most optimally target the tissues in that region.

**Electronic Therapy Records (ETR)**

No need to remember which protocol you used on which patient on which date.
- Customizable Patient Protocols
- Viewable and Sortable Treatment History
- USB Exportable Records

**Putting It All Together**

We’ve done all the thinking for you. Once you input the specific details of the patient and condition, all of the treatment parameters are neatly organized for you in just three clicks. 1-2-3 Treat!
HOW TO WRITE A CASE STUDY

If you would like to share an interesting case, we encourage you to prepare a Case Study Report and submit it either to K-LaserUSA, or to a Chiropractic Research Journal. Class IV Laser Therapy will continue to be a rapidly growing field in the years ahead. You will benefit professionally, and patients around the world will benefit clinically from the effort you put into a Case Study.

The case study could include the following headings and or categories:

1. Abstract
2. Introduction
3. Case report
4. Discussion
5. Conclusion
6. References

Abstract:
The abstract or synopsis summarizes the main points of the case study including 1) the purpose of the case report, 2) the basic procedures followed, 3) the main findings and 4) the principal conclusions. The abstract might include the following headings and content:

- **Objective:** Why is the case study being presented?
- **Clinical features:** A brief overview of the patient's presentation and diagnosis.
- **Intervention and Outcomes:** An overview of what was done and what happened as a result.
- **Conclusions:** This is a brief statement of what you feel the significance of the case is.

Introduction:
This discussion should give the reader a general overview of the topic you are about to discuss relative to your case presentation. It could consist of one to two paragraphs as to why this case is important. If you were writing about the effects of laser therapy on a patient with diabetic neuropathy, for instance, you might want to discuss the condition in general. The same would be true with more mundane topics as neck pain, headaches and other neuromusculoskeletal conditions. Keep in mind that a case study does not have to involve a dramatic life-threatening illness. Case studies are needed on K-Laser® Treatment care for a wide variety of conditions.

Case Report:
This section should detail the pertinent history, chief complaint and exam findings regarding the case under discussion. You should discuss what type of care was instituted and the results of that care. This is one of the most important parts of a case report. Document the care in such a way that the procedures performed are readily identifiable. Describe progress from one visit to the next.

Give biographical information about the patient if appropriate. Be sure to document the total number of Joules delivered, as well as the approximate area in square centimeters that you treated. From that you can calculate the energy density in Joules per sq. centimeter (J/cm²).

Discussion:
This section could include a more detailed discussion of the condition under investigation. A review of the literature would be appropriate as well as a review of the literature relative to common treatment protocols. Review any chiropractic or laser therapy literature related to this condition. Perhaps others have written on the topic and have seen similar results as you. You could conclude this section by making hypotheses regarding the literature and your experience with this case.
HOW TO WRITE A CASE STUDY

Conclusion:
This should be a concise discussion of what you concluded as a result of your review of literature and your experience in this case as well as the significant features of the case. Discussion of the clinical importance of the case can also be presented here. A statement regarding limitations of your study and the prospect for future research could be included here.

References:
List all relevant references that support your case study report and the statements made in it. Although this process may appear tedious, guidelines exist on how to list the references, and once you get going, it's pretty simple and straightforward. You can also look at examples of case studies from JSWR, www.jswr.com, and other health-related in libraries to get ideas and guidance on how to organize and write your case study.

Also, it's very important for you to remember that your case study can be solely about the reduction pain, muscle spasm or improved range of motion in your patient and does not have to be about the amelioration of some other disease or condition.

We encourage you to take time to pick one of your patients who has experienced a positive benefit from K-Laser Treatments and go through this process.

Figure 1: Case Study Example

Limb Blood Flow After Class 4 Laser Therapy
Kelly A. Larkin, MS, CAT(C)*; Jeffrey S. Martin, PhD*; Elizabeth H. Zeanaah, MS*; Jerry M. True, DC, FIACNCT; Randy W. Braith, PhD*; Paul A. Borsa, PhD, ATC, FACSM*

*Department of Applied Physiology and Kinesiology, University of Florida, Gainesville; 1Palm City, FL

Context: Laser therapy is purported to improve blood flow in soft tissues. Modulating circulation would promote healing by controlling postinjury ischemia, hypoxia, edema, and secondary tissue damage. However, no studies have quantified these responses to laser therapy.

Objective: To determine a therapeutic dose range for laser therapy for increasing blood flow to the forearm.

Design: Cross-over study.

Setting: Controlled laboratory setting.

Participants or Other Participants: Ten healthy, college-aged men (age: 25.8 ± 2.1 years, height: 177.8 ± 6.2 cm, weight: 75.8 ± 1.1 kg) with no current history of injury to the upper extremity or cardiovascular conditions.

Intervention: A class 4 laser device was used to treat the bicipital brachii muscles. Each subject was treated for 1 to 4 seconds, for a total of 4 minutes. Each participant received 4 doses of laser therapy: sham, 1 W, 3 W, and 6 W.

Main Outcome Measure(s): The dependent variables were changes in blood flow, measured using venous occlusion plethysmography. We used a repeated-measures analysis of variance to analyze changes in blood flow for each dose at 2, 3, and 4 minutes and at 1, 2, 3, 4, and 5 minutes after treatment. The Student's t-test was conducted to examine differences over time.

Results: Compared with baseline, blood flow increased over time with the 3-W treatment (F[3, 10] = 3.488, p < 0.01) at minutes 4 of treatment (2.417 ± 0.342 vs. 2.739 ± 0.501 mL/min per 100 mL tissue, P = 0.023) and at 2 minutes (2.417 ± 0.342 vs. 2.739 ± 0.501 mL/min per 100 mL tissue, P = 0.07) and 2 minutes (2.417 ± 0.342 vs. 2.739 ± 0.501 mL/min per 100 mL tissue, P = 0.023) after treatment. The sham, 1-W, and 6-W treatment doses did not change blood flow from baseline at any time point.

Conclusions: Laser therapy at the 3-W (300 J) dose level is an effective treatment modality to increase blood flow in the soft tissues.

Key Words: therapeutic modalities, circulation, musculoskeletal injuries.

Key Points:
- Using a class 4 laser in a human clinical model, we found a protocol response effect: a 3-W protocol at a 60% duty cycle applied to the bicipital brachii muscle was the most effective for increasing blood flow to the bicipital brachii.
- Laser therapy is an effective, noninvasive treatment modality for improving blood flow and perhaps tissue healing in the clinical setting.
**ATLAS OF K-LASER® TREATMENTS**

The K-Laser® Device has built-in therapy presets that are broken down by body part and clinical indication. This unique capability sets it apart from other Class IV therapy lasers. Therapy presets create an ease of use and treatment consistency that will further enhance your clinical results with the K-Laser® Device.

Keep in mind that different frequencies elicit a different response from the tissues, refer back to the section on Frequency Modulation. You should have a general knowledge of the benefits of the various frequencies, but in the clinical operation of your K-Laser® Device it is more important to focus your attention on the patient.

Most K-Laser® Therapy Presets will start and finish in continuous wave (CW) mode to promote both initial and “cleanup” circulation, and then automatically progress through various Frequency Modulated phases depending on the tissue-make up of the particular anatomy. Remember that in Frequency Modulated (Hz) mode you can hold the treatment wand in one place for a few seconds, and use the ‘pushing’ technique to apply mild pressure to trigger points, or areas where you want deeper laser penetration. When delivering continuous wave, be sure to use the scanning method.

K-Laser® Therapy Presets are selected based on body type, anatomy, chronicity, and pain level. Based upon your clinical judgment, use the preset that most closely matches the patient’s condition. These subcategories are meant to refine your K-Laser® Treatment delivery. Use the subcategory that best matches your clinical goal for that treatment, and proceed.

(Notes: The frequencies, wattages and time duration may differ from the therapy presets in your K-Laser® Device. With the K-Laser® K-CUBE SERIES™ upgradable software, minor adjustments can be made to these settings.)

**Anatomy: Cervical - Body Type: Ecto - Chronicity: Acute - Pain Level: Low**

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Phase Time (Sec.)</th>
<th>Peak Power (Watt)</th>
<th>Avg. Power (Watt)</th>
<th>Joules</th>
<th>CW, ISP, or Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>CW</td>
<td>24 sec.</td>
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<td>4.8w</td>
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<td>Total Joules</td>
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</table>
**ATLAS OF K-LASER® TREATMENTS**

**Anatomy: Cervical - Body Type: Meso - Chronicity: Chronic - Pain Level: High**

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Phase Time (Sec.)</th>
<th>Peak Power (Watt)</th>
<th>Avg. Power (Watt)</th>
<th>Joules</th>
<th>CW, ISP, or Hz</th>
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Examine the cervical pain settings above, comparing the presets for "ecto" body type with acute, low pain to the "meso" individual with intense, chronic pain. Notice the changes made within the software based on the inputs of your patient’s characteristics. The key difference is in the individual phase times and power settings. Notice, however, that the frequencies used in both protocols are the same, since the tissue makeup (percentage of bone, connective tissue, and smooth muscle) is the same in both cases. The size of the individual, combined with the pain level and chronicity, change both the amount of dose to be administered AND the depth to which that dose must be delivered, and so these changes are made automatically with your inputs.

Would your clinical outcome be significantly different if you used the acute setting versus the chronic? It may — but once again do not let the choice of a therapy preset slow you down. Choose the one that fits best, then focus your attention on the patient and deliver the best K-Laser® Treatment you possibly can.

The following pages contain treatment suggestions and Clinical Pearls for delivering K-Laser® Class IV Laser Therapy Treatments to your patients. We encourage you to read the preceding sections of this Manual, especially the sections on K-Laser® Treatment dosage, treatment tips to improve your clinical results, and delivery techniques.

The Treatment Atlas is broken down by body part, in much the same way that the K-Laser® Therapy Presets are. The sections in the Treatment Atlas and the presets on the K-Laser® Device may not necessarily match up with each other on a one-to-one basis. This Atlas is not meant to be a "cookbook" from which to deliver treatments, but rather a resource of clinical suggestions to assist you in your K-Laser® Treatment delivery.
ATLAS OF K-LASER® TREATMENTS

This section of the Atlas will give you suggestions on where to treat, what to expect during the course of treatment, and suggested treatment plans. These are to be a guideline, only. Be sure to read the section on page 41 "Treatment Plan Formulation".

Laser therapy is a proven modality for the treatment of myofascial trigger points, and the accompanying myofascial pain syndromes. Be sure to treat trigger points in the area, as well as distant trigger points that may be exacerbating the patient’s condition.

The anatomy figures shown in this Atlas are for preliminary guidance only. It is very difficult to represent a 3-dimensional, active laser therapy treatment on a static 2-dimensional picture.

CHART OF SUGGESTED AVERAGE POWER SETTINGS

The chart to the right gives suggested power settings for various body parts on an "average" sized person. It is meant to give you the basic idea behind K-Laser® Treatment delivery; it is not meant to be a definitive statement on what power to use with all patients. The big picture is that you would not use 10 Watts on a TMJ (too much power, causing inhibition of healing, possibly increasing the patient's pain); and you likewise would not use 2 Watts on a large patient's lumbar disc (too little power, ineffective dosage at target tissues).

Acute conditions should be treated with slightly less power, whereas chronic conditions can be treated with slightly higher power. Be sure to read and understand the sections on laser therapy dosage along with understanding this chart.

If you have specific questions on K-Laser® Treatment power and dosage, be sure to use the free Clinician Telephone Support supplied by K-LaserUSA at 866-595-7749.
HEAD TREATMENTS

DIAGNOSIS:

ACUTE / LOWER PAIN:
Conditions Include:
- Tension Headache
- Head Trauma
- Jaw/Facial Pain
- Sinus Pain

CHRONIC / HIGHER PAIN:
Conditions Include:
- Migraine Headache
- Chronic Jaw Pain
- Bell’s Palsy
- Trigeminal Neuralgia

TREATMENT TECHNIQUES:
The K-Laser® Treatment can be applied over the entire head. Use caution to avoid direct exposure into eyes. Have patient seated wearing safety glasses holding head still. Treatment can be given over the forehead, temple, and cheeks. Darker hair and around the hairline will produce heat more rapidly than on bare skin. Use caution and keep handpiece moving to reduce heat accumulation. Treatment can be applied over the temporalis, masseter, and sub-occipital musculature. It can also be used over the frontal and maxillary sinuses to relieve sinus discomfort.

ACUTE / LOWER PAIN:

WHAT TO EXPECT:
Patient should feel reduction or dulling of pain during or immediately after treatment. Expect increase in sinus drainage.

CHRONIC / HIGHER PAIN:

It could take 3-5 visits before a change is noted. Pain may increase a few hours after treatment.

RECOMMENDED TREATMENT PLAN:
- Every day for 3 days.
- Then every other day for 3 treatments.
- The majority of cases will be cleared up in 6 visits.

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HELPFUL TIPS:
During all treatments the handpiece will be contacting the skin with the exception of open wounds. Get feedback from patient in regards to comfort level, heat tolerance, and sensitivity. If patient experiences increased symptoms or no change at all in the first 3-5 visits, reduce wattage by 30%. If after 3-5 visits at reduced wattage, the condition is still not responding, incrementally increase wattage above the preset protocol for 3-5 visits. Always locate the most sensitive or painful trigger point before moving onto secondary or tertiary points. This will enable you to address the areas producing most discomfort to the patient. (Refer to page 22 "Reduce Wattage").
CERVICAL TREATMENTS
CERVICAL TREATMENTS

DIAGNOSIS:

ACUTE / LOWER PAIN:
Conditions Include:
- Motor Vehicle Accident
- Sports Injury
- Arthritis
- Cervical Strain/Sprain

CHRONIC / HIGHER PAIN:
Conditions Include:
- Arthritis
- Post Surgical
- Past Motor Vehicle Accident
- Cervical Disc Disease

TREATMENT TECHNIQUES:
While in CW utilize the Scanning Technique on the posterior region of the neck and all supporting musculature involved with the chief complaint. As the protocol shifts into the modulated phases, you will use the pushing or pressing technique. Push into the muscle or trigger point for 3 to 5 seconds before advancing to the next point.

ACUTE / LOWER PAIN:

WHAT TO EXPECT:
Range of motion should improve and pain level should diminish in one to three treatments.

CHRONIC / HIGHER PAIN:

WHAT TO EXPECT:
Use K-Laser® Therapy before adjustments or soft tissue work. It could take 2-4 treatments before a positive change is noted.

RECOMMENDED TREATMENT PLAN:

ACUTE / LOWER PAIN:
- Every day for 3 days.
- Then every other day for 3 treatments.
- The majority of cases will be cleared up in 6 visits.

CHRONIC / HIGHER PAIN:
- Every other day for 4-5 treatments.
- Then once a week for 3 weeks.
- Some cases may require ongoing treatments, once every 3-6 weeks.
HELPFUL TIPS:
During all treatments the handpiece will be contacting the skin with the exception of open wounds. Get feedback from patient in regards to comfort level, heat tolerance, and sensitivity. If patient experiences increased symptoms or no change at all in the first 3-5 visits, reduce wattage by 30%. If after 3-5 visits at reduced wattage, the condition is still not responding, incrementally increase wattage above the preset protocol for 3-5 visits. Always locate the most sensitive or painful trigger point before moving onto secondary or tertiary points. This will enable you to address the areas producing most discomfort to the patient. (Refer to page 22 “Reduce Wattage”).
SHOULDER TREATMENTS
SHOULDER TREATMENTS

DIAGNOSIS:

ACUTE / LOWER PAIN:

Conditions Include:
- Sports Injury
- Muscle Strain
- Rotator Cuff Injury
- Bursitis

CHRONIC / HIGHER PAIN:

Conditions Include:
- Past Sports Injuries
- Frozen Shoulder
- Past Rotator Cuff Tears/Injuries
- Chronic Bursitis
- Past Shoulder Surgery

TREATMENT TECHNIQUES:

Have patient perform range of motion and identify restriction and muscles involved. Start treatment over upper division of the trapezius muscles and work laterally to the symptomatic shoulder. Treat anterior, lateral and posterior muscles of the shoulder girdle. Pay particular attention to muscles involved in restricted range of motion. Palpate for tenderness over supraspinatus insertion and teres minor. If tender, use pressing technique while applying laser to these areas. While in CW, sweep the region of the trapezius, pectoral, and deltoid musculature of the involved side.

HELPFUL TIPS:
A beneficial exercise for shoulder pain is to have the patient perform CODMAN SHOULDER EXERCISES at home. Do not forget to address upper rib head, clavicle and humeral head misalignment.
SHOULDER TREATMENTS

ACUTE / LOWER PAIN:

WHAT TO EXPECT:
Range of motion should improve and pain levels diminish in 2-4 treatments.

RECOMMENDED TREATMENT PLAN:
- Every day for 3 days.
- Then every other day for 4 treatments.
- After that, once or twice a week until the condition is resolved.

CHRONIC / HIGHER PAIN:

WHAT TO EXPECT:
In cases of severe restricted shoulder range of motion, it could take 4-6 visits before a positive change is noted. There may be post-treatment soreness a few hours afterwards.

RECOMMENDED TREATMENT PLAN:
- Every other day for 4-5 treatments.
- Then twice a week until resolved.
- Use K-Laser Therapy before soft tissue work or adjustment, especially for frozen shoulder.

HELPFUL TIPS:
During all treatments the handpiece will be contacting the skin with the exception of open wounds. Get feedback from patient in regards to comfort level, heat tolerance, and sensitivity. If patient experiences increased symptoms or no change at all in the first 3-5 visits, reduce wattage by 30%. If after 3-5 visits at reduced wattage, the condition is still not responding, incrementally increase wattage above the preset protocol for 3-5 visits. Always locate the most sensitive or painful trigger point before moving onto secondary or tertiary points. This will enable you to address the areas producing most discomfort to the patient. (refer to page 22 "Reduce Wattage").
DIAGNOSIS:

ACUTE / LOWER PAIN:

Conditions Include:
- Lateral Epicondylitis
- Trauma

CHRONIC / HIGHER PAIN:

Conditions Include:
- History of Trauma
- Past Sports Injuries
- Repetitive Motion Injuries

TREATMENT TECHNIQUES:

Many cases of elbow pain seen in the office stem from lateral epicondylitis. Palpation over the radial head will yield pain as will external rotation of the hand with internal rotational resistance by the patient. Laser treatment should focus on the inflamed insertion points near the radial head and follow down the wrist extensor musculature. Treat trigger points above and below elbow. Other considerations of elbow pain can be trigger points in the triceps muscle. Utilize the pressing technique into the triceps insertion points on the elbow. Point tenderness over the ulnar groove may indicate inflammation. Due to the boney nature of this area, utilize the scanning technique over the ulnar groove.

HELPFUL TIPS:

Have patient use a brace or support and discontinue aggravating activity until symptoms are under control. It is also beneficial to have them perform cryo-therapy at home and apply a topical anti-inflammatory gel such as Traumeel.
ELBOW TREATMENTS

ACUTE / LOWER PAIN:

WHAT TO EXPECT:
Range of motion should improve and pain levels diminish in 2-4 treatments. Be sure to wait seven days after corticosteroid injections in the treated area.

RECOMMENDED TREATMENT PLAN:
• Every day for 2 days.
• Then every other day for 3 treatments.
• Then re-evaluate.

CHRONIC / HIGHER PAIN:

It could take 3-5 visits before a positive change is noted. If not, increase the total dosage by increasing treatment time. Run through the preset 1½ to 2 times, covering a larger area above and below the elbow.

RECOMMENDED TREATMENT PLAN:
• Every day for 3 treatments.
• Then every other day for 5 treatments.
• Then re-evaluate.

HELPFUL TIPS:
During all treatments the handpiece will be contacting the skin with the exception of open wounds. Get feedback from patient in regards to comfort level, heat tolerance, and sensitivity. If patient experiences increased symptoms or no change at all in the first 3-5 visits, reduce wattage by 30%. If after 3-5 visits at reduced wattage, the condition is still not responding, incrementally increase wattage above the preset protocol for 3-5 visits. Always locate the most sensitive or painful trigger point before moving onto secondary or tertiary points. This will enable you to address the areas producing most discomfort to the patient. (refer to page 22 “Reduce Wattage”).

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WRIST / HAND TREATMENTS
WRIST / HAND TREATMENTS

DIAGNOSIS:

ACUTE / LOWER PAIN:
Conditions Include:
- Trauma
- Arthritis
- Trigger Finger
- Dequervain’s Syndrome

CHRONIC / HIGHER PAIN:
Conditions Include:
- Repetitive Use Injuries
- Post Surgical with Chronic Scar Tissue
- History of Bone Fracture
- Arthritis

TREATMENT TECHNIQUES:
Start K-Laser® Treatment proximal to wrist, even at anterior elbow. Focus on the flexor tendons in the forearm working down to the carpal tunnel. Applying directly over the carpal tunnel will aid in reducing inflammation in the carpal tunnel. Treat trigger points in forearm muscles.

HELPFUL TIPS:
Vitamin B6 acts as a natural diuretic and helps reduce fluid buildup in the carpal tunnel. Use of a neutral splint during sleep keeps patient from sleeping on hands with wrists flexed. Have patient follow up at home with any exercises or therapy (cryotherapy/rehab exercises) that will aid in the relief of symptoms.

Check subscapularis muscle; it is the most commonly overlooked cause of wrist pain. Laser one full cycle on the subscapularis and use acupressure techniques. Carpal Tunnel Syndrome is usually a ‘Double Crush’ issue. Always check scalenes, first rib and infraspinatus. Laser the cervical spine, stellate ganglion, entire hand, wrist, and trace the nerves down the arm from the brachial plexus.
WRIST / HAND TREATMENTS

ACUTE / LOWER PAIN:

WHAT TO EXPECT:
Pain should decrease and range of motion increase in 2-4 treatments.

CHRONIC / HIGHER PAIN:

Read specific conditions if treating carpal tunnel syndrome. Pain should decrease within 3-4 treatments. Increase dosage by increasing treatment time if there is no positive response after 4 treatments. Run through preset additional time, applying K-Laser® Therapy to trigger points in forearm muscles.

RECOMMENDED TREATMENT PLAN:

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<th>CHRONIC / HIGHER PAIN</th>
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<tr>
<td>Then every other day for 3 treatments.</td>
<td>Then every other day for 4 treatments.</td>
</tr>
<tr>
<td>Then re-evaluate.</td>
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SPECIFIC CONDITIONS:

Carpal Tunnel - Start with a cervical setting over cervical nerve roots. Have patient open and close hand a few times during the entire treatment. Work slowly out over brachial plexus/ nerves outside of neck and into shoulder. Use an elbow setting and apply from elbow on down to wrist.

Dupuytren Contracture - Treat over the contracted flexor tendons in the palm of the hand as well as over the flexor tendons in the wrist and lower arm.

What To Expect:
Use K-Laser® Treatment in conjunction with soft-tissue work, massage, adjustments, etc. Tingling in nerves during K-Laser® Therapy application or after treatment is a good sign. It indicates the laser is having an effect on the cellular ion channels.

Recommended Treatment Plan:
For severe cases, treat daily for 3 days, then every other day for 3 treatments. Moderate cases, every day for 2 days, then every other day for 3 treatments. Mild cases, every other day for 4 visits. Then re-evaluate at the end of this time.
THORACIC TREATMENTS

DIAGNOSIS:

ACUTE / LOWER PAIN:

Conditions Include:
- Arthritis
- Mid-Back Tension
- Rib Misalignments
- Spinal Misalignment
- Scoliosis
- Shingles

CHRONIC / HIGHER PAIN:

Conditions Include:
- Thoracic Disc Disease
- DISH
- Ankylosing Spondylitis

TREATMENT TECHNIQUES:

Apply K-Laser® Treatment slowly over entire affected area. Utilizing both Pushing and Scanning techniques, slowly treat over the thoracic paraspinals. Utilize a pace that enables the patient to feel some warmth.

HELPFUL TIPS:

Avoid K-Laser® Therapy directly over tattoos. Do not forget to address bilateral rib head displacement and thoracic fixation.

Thoracic pain is ALWAYS linked to some phase of the Upper Crossed Syndrome. There will usually be undiagnosed trigger points in the infraspinatus and scalenes. If you find trigger points make sure to use the pushing technique directly on them and then proceed to manual therapy. Thoracic paraspinal muscles become synergistically dominant when the transversospinalis and abdominal stabilization mechanisms are dysfunctional. Weakness of interspinal muscles allows increased inter-segmental rotational and translational stress increasing mechanical loading to the annular rings in the disc due to repetitive microtrauma.
THORACIC TREATMENTS

ACUTE / LOWER PAIN:

WHAT TO EXPECT:

For shingles, target the dorsal root ganglion, just lateral to the spinous process of the affected level, and two above and below. There may be post-treatment soreness. Ramp up the dosage, start with a lower dosage and increase on subsequent visits as needed. Treat trigger points in paraspinal muscles and upper back.

RECOMMENDED TREATMENT PLAN:

• Every day for 3 days.
• Then every other day for 3 treatments.
• Apply K-Laser® Treatment before adjustment or massage.

CHRONIC / HIGHER PAIN:

It could take 3-5 treatments before a positive change is felt. Chronic cases may require ongoing care.

RECOMMENDED TREATMENT PLAN:

• Every day for 3 days.
• Then every other day for 5 treatments.
• May require ongoing treatments every 2-4 weeks.

HELPFUL TIPS:

During all treatments the handpiece will be contacting the skin with the exception of open wounds. Get feedback from patient in regards to comfort level, heat tolerance, and sensitivity. If patient experiences increased symptoms or no change at all in the first 3-5 visits, reduce wattage by 30%. If after 3-5 visits at reduced wattage, the condition is still not responding, incrementally increase wattage above the preset protocol for 3-5 visits. Always locate the most sensitive or painful trigger point before moving onto secondary or tertiary points. This will enable you to address the areas producing most discomfort to the patient. (refer to page 22 "Reduce Wattage").

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LUMBAR TREATMENTS

DIAGNOSIS:

ACUTE / LOWER PAIN:
- Conditions Include:
  - Low Back Strain/Sprain
  - Hot Lumbar Disc
  - Post-Surgical Pain
  - Work Injury

CHRONIC / HIGHER PAIN:
- Conditions Include:
  - Lumbar Disc Disease
  - History of Spinal Surgery
  - History of Work Injuries

TREATMENT TECHNIQUES:

Apply K-Laser® Treatment over entire low back region. You could have patient seated in a wobble chair or on an exercise ball, so they can perform range of motion during treatment. Flexion distraction or lumbar decompression work well in conjunction with K-Laser® Treatment. Utilizing both scanning and pressing technique, move slowly enough so the patient can feel warming on the body. It may be necessary to treat trigger points in the gluteal muscles that are commonly associated with Low Back Pain. K-Laser® Therapy to trigger points in bilateral iliopsoas muscles as contracture of these muscles is commonly associated with low back pain. In the presence of sciatic pain, be sure to treat over the path of the related sciatic pathway.

HELPFUL TIPS:

It is not advisable to perform range of motion or flexion distraction during the acute inflammatory phase, especially when facet inflammation is present. In the presence of sciatica, be sure to perform PNF stretch on the piriformis muscle on the related side of sciatic pain. Apply laser to trigger points deep in the piriformis using the pushing/pressing technique. In the event the lower back is obscured by tattoos, roll the patient on their side and apply K-Laser® Therapy from the ventral side of the body. Pay close attention to the area of the right and left lower abdominal quadrants. Gluteus medius and minimus are the most likely cause of intense low back pain. Always release them first before trying to address the lumbar vertebrae or paraspinals. The paraspinals are splinting because of the gluteus trigger points. For groin related pain, check for anterior ilium and the tensor fascia lata, pectineus, and insertion of the iliopsoas.
**LUMBAR TREATMENTS**

**ACUTE / LOWER PAIN:**

**WHAT TO EXPECT:**

If you can do some form of range of motion during treatment, the patient should notice reduced pain and increased ROM in 1-3 treatments. Have patient walk up and down hallway, or even around the block after treatment.

**RECOMMENDED TREATMENT PLAN:**

- Every day for 3 days.
- Then every other day for 4-5 treatments.

**CHRONIC / HIGHER PAIN:**

There may be post-treatment soreness, especially in smokers or patients taking several medications. Advise them to drink extra water the rest of the day after treatment. It could take 3-5 treatments before positive change is noted. Increase dosage by increasing treatment time as needed.

**HELPFUL TIPS:**

During all treatments the handpiece will be contacting the skin with the exception of open wounds. Get feedback from patient in regards to comfort level, heat tolerance, and sensitivity. If patient experiences increased symptoms or no change at all in the first 3-5 visits, reduce wattage by 30%. If after 3-5 visits at reduced wattage, the condition is still not responding, incrementally increase wattage above the preset protocol for 3-5 visits. Always locate the most sensitive or painful trigger point before moving onto secondary or tertiary points. This will enable you to address the areas producing most discomfort to the patient. (refer to page 22 "Reduce Wattage").
HIP TREATMENTS
HIP TREATMENTS

HIP / SACROILIAC

DIAGNOSIS:

ACUTE / LOWER PAIN:
Conditions Include:
- Sports Injury
- Bursitis
- Iliotibial Band Syndrome
- Arthritis

CHRONIC / HIGHER PAIN:
Conditions Include:
- Hip Replacement Surgery
- Arthritis
- History of Hip Injury/Torn Hip Labrum

TREATMENT TECHNIQUES:
Apply K-Laser™ Treatment over front, side and back of hip. Have patient side-lying so they can flex and extend hip during treatment. Using pushing technique, treat trigger points in iliopsoas and gluteal muscles. Pay attention to area over the greater trochanter to reduce inflammation at the insertion of the hip abductor. Treat from the front to get the laser into the hip joint. There are no contraindications to treating patients with metal hip replacements.

HELPFUL TIPS:
Most hip pain that is diagnosed as arthritis or bursitis can be traced to an active or latent trigger point. Even if the diagnoses are correct of arthritis and/or bursitis, there is ALWAYS a biomechanical issue caused by trigger points inhibiting muscle. Never assume it is only a joint problem. There is always muscular involvement. Do not neglect the inner thigh muscles either. When they are overactive, they inhibit the gluteus medius/minimus and the TFL and ITB take up the slack, causing iliofemoral compensations. That is why there is usually groin pain associated with hip problems. Also, check for a history of ankle sprains. Following ankle sprains, it has been proven that the tensor fascia latae and gluteus minimus become dominant, leading to internal rotation of the femur which increases stress in the lower leg and knee.
HIP TREATMENTS

**HIP / SACROILIAC**

**ACUTE / LOWER PAIN:**

**WHAT TO EXPECT:**

- Have the patient walk after treatment. Patient should notice decreased pain and improved ROM in 2-4 treatments. If not, increase dosage and make sure you are treating trigger points and using ROM during treatment.

**RECOMMENDED TREATMENT PLAN:**

- Every day for 3 days.
- Then every other day for 4-5 treatments.

**CHRONIC / HIGHER PAIN:**

**WHAT TO EXPECT:**

- Pain should decrease and ROM increase in 2-4 treatments. Have patient walk after treatment. Wait at least seven days after steroid injection into the joint.

**RECOMMENDED TREATMENT PLAN:**

- Every day for 3 days.
- Then every other day for 5-6 treatments.
- Chronic arthritis, with thinning of the joint cartilage, may require ongoing treatments every 1-4 weeks.

**TREATMENT TECHNIQUES:**

Start **K-Laser®** Treatment over the lumbar nerve roots on the affected side, and work down through the SI joint. Utilize both scanning and pressing techniques until patient can feel the thermal effect on the skin. Treat trigger points in lower back and gluteal muscles. **Apply K-Laser®** Treatment before adjusting the SI.

**HELPFUL TIPS:**

During all treatments the handpiece will be contacting the skin with the exception of open wounds. Get feedback from patient in regards to comfort level, heat tolerance, and sensitivity. If patient experiences increased symptoms or no change at all in the first 3-5 visits, reduce wattage by 30%. If after 3-5 visits at reduced wattage, the condition is still not responding, incrementally increase wattage above the preset protocol for 3-5 visits. Always locate the most sensitive or painful trigger point before moving onto secondary or tertiary points. This will enable you to address the areas producing most discomfort to the patient. (refer to page 22 "Reduce Wattage").
KNEE TREATMENTS
KNEE TREATMENTS

DIAGNOSIS:

ACUTE / LOWER PAIN:
Conditions Include:
- Post-Surgical Pain
- Arthritis
- Sports Injury
- Meniscus/Cartilage Damage

CHRONIC / HIGHER PAIN:
Conditions Include:
- Past Sports Injuries
- Knee Replacement Surgery
- Past Meniscus/Cartilage Damage
- Arthritis with Thinning Cartilage Notable on X-ray.

TREATMENT TECHNIQUES:

With patient seated or prone, begin K-Laser Therapy using the scanning and pressing technique on the quadriceps muscles with particular attention paid to the insertion points above the patella. Pay special attention to the iliotibial band on the lateral knee. This is a very common cause of knee pain in runners. Apply treatment to the lateral and medial collateral ligaments as well as the patellar tendon both inferior and superior to the patella. With patient in the prone position, apply K-Laser Therapy to the popliteal fossa for better penetration into the knee joint and stimulation of the circulatory vessels.

HELPFUL TIPS:
Tight hamstrings create posterior pelvic tilt and a functional leg length difference. Biceps femoris becomes overactive with a weak gluteus maximus (tights psoas) and creates a proximal tibio-fibular joint dysfunction. This effects sagittal plane dorsiflexion. Tight adductors cause myokinemnic inhibition of the gluteus medius causing compensations of the TFL. Overuse of the gluteus minimus as synergist can lead to superior gluteal nerve entrapment, which can mimic lateral knee pain. Identify weakness in the vastus lateralis or medialis by looking at the alignment of the patella. The patella will track to the opposite side of the weaker muscle. This can be identified by the alignment of the center of the patella and the tibial tuberosity. Have patient perform exercises to isolate and strengthen the weak muscle.

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KNEE TREATMENTS

ACUTE / LOWER PAIN:

WHAT TO EXPECT:
You may see reduced swelling on the first treatment, and should notice reduced pain and increased ROM in 1-3 treatments. Have the patient walk up and down the hallway to give feedback.

RECOMMENDED TREATMENT PLAN:
- Every day for 3 days.
- Then every other day for 3 treatments.

CHRONIC / HIGHER PAIN:

Pain should decrease in 2-4 treatments. You can treat over metal implants with knee replacements. Wait at least seven days after a steroid injection into the joint before applying K-Laser® Treatment.

RECOMMENDED TREATMENT PLAN:
- Every day for 3 days.
- Then every other day for 4-6 treatments.
- If the joint cartilage is very thin, it will require ongoing treatments, every 2-4 weeks or as needed.

HELPFUL TIPS:
During all treatments the handpiece will be contacting the skin with the exception of open wounds. Get feedback from patient in regards to comfort level, heat tolerance, and sensitivity. If patient experiences increased symptoms or no change at all in the first 3-5 visits, reduce wattage by 30%. If after 3-5 visits at reduced wattage, the condition is still not responding, incrementally increase wattage above the preset protocol for 3-5 visits. Always locate the most sensitive or painful trigger point before moving onto secondary or tertiary points. This will enable you to address the areas producing most discomfort to the patient. (refer to page 22 "Reduce Wattage").
FOOT / HEEL TREATMENTS
FOOT / HEEL TREATMENTS

DIAGNOSIS:

ACUTE / LOWER PAIN:
Conditions Include:
- Heel Pain
- Toe pain
- Sports Injury

CHRONIC / HIGHER PAIN:
Conditions Include:
- History of Broken Foot
- Bunion Pain

TREATMENT TECHNIQUES:

K-Laser® Treatment is very effective in treating the pain associated with heel spurs, plantar fasciitis, bunion pain, neuroma pain, fractured toe pain, tendonitis. Heel pain associated with bone spurs should be treated using pressing and scanning technique over plantar surface of foot with particular attention paid to the area of the spur. Often associated with heel pain are trigger points in the gastrocnemius and soleus. Scan and press over the tender trigger points in the gastrocnemius and soleus to address other causes of heel pain. Bunion and neuroma pain can be addressed with treatment directly over the involved area. When treating pain associated with neuromas, apply treatment through the dorsum and plantar surface of the foot. Bunion and neuroma pain will not require a heavy dosage of therapy so long treatment times at high power are not necessary. See special notes on treating plantar fasciitis.

HELPFUL TIP:
Always check the soleus, gastrocnemius, tibialis posterior, tibialis anterior, peroneals and flexor hallucis in a foot problem. Heel spurs and fasciitis do not simply appear out of nowhere, there is chronic microtrauma involved with these conditions. If the biomechanical and muscular components are not corrected, short term healing will occur.
### FOOT / HEEL TREATMENTS

#### ACUTE / LOWER PAIN:

**WHAT TO EXPECT:**
- Pain should decrease in 1-3 treatments.
- If needed, increase dosage by increasing treatment time.

**RECOMMENDED TREATMENT PLAN:**
- Every day for 2 days.
- Then every other day for 3-5 treatments.

#### CHRONIC / HIGHER PAIN:

**WHAT TO EXPECT:**
- It may take 3-5 treatments before a change is noted. Increase dosage if no change is observed after third treatment.

**RECOMMENDED TREATMENT PLAN:**
- Every day for 3 days.
- Then every other day for 4-6 treatments.

### SPECIFIC CONDITIONS:

**Plantar Fasciitis** - Use an ankle setting and start application behind knee. Apply K-Laser® Therapy over trigger points in calf muscles. Have patient flex and extend foot/ankle during application. Then use ankle setting again, apply from back of ankle and over entire bottom of foot.

**What To Expect:**
- Patient may experience tingling or other sensations in nerve distribution, either during K-Laser® Treatment or a few hours afterwards. Pain level and soreness may increase a few hours after the first few treatments.

**Recommended Treatment Plan:**
- Treat every day for 3 days, then every other day for 3-5 treatments, then every third day for 5-7 treatments.

### HELPFUL TIPS:

During all treatments the handpiece will be contacting the skin with the exception of open wounds. Get feedback from patient in regards to comfort level, heat tolerance, and sensitivity. If patient experiences increased symptoms or no change at all in the first 3-5 visits, reduce wattage by 30%. If after 3-5 visits at reduced wattage, the condition is still not responding, incrementally increase wattage above the preset protocol for 3-5 visits. Always locate the most sensitive or painful trigger point before moving onto secondary or tertiary points. This will enable you to address the areas producing most discomfort to the patient. (refer to page 22 "Reduce Wattage").
DIAGNOSIS:

ACUTE / LOWER PAIN:
Conditions Include:
- Ankle Sprain
- Arthritis
- Trauma
- Swelling

CHRONIC / HIGHER PAIN:
Conditions Include:
- History of Broken/Sprained Ankle
- Gout Pain affecting the Ankle

TREATMENT TECHNIQUES:
In addition to acute and chronic indications listed above, K-Laser® Treatment is also effective for treating pain associated with tendonitis and inflammation of the retinaculum of the foot and ankle. Due to the lack of soft tissue surrounding the ankle, the scanning technique will be utilized most. Apply over the regions where the pain is most prevalent. In addition to the focal site of pain, scan the entire ankle. With Achilles tendonitis, scan the Achilles tendon and use the pressing technique in the soleus and gastrocnemius. While treating ankle sprain and strain, use the scanning technique to encompass the entire region of swelling. Do not push into the edema as the patient will likely feel considerable pain in the acute phase of this type of injury.
**ANKLE TREATMENTS**

<table>
<thead>
<tr>
<th>ACUTE / LOWER PAIN:</th>
<th>CHRONIC / HIGHER PAIN:</th>
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<tbody>
<tr>
<td><strong>WHAT TO EXPECT:</strong></td>
<td></td>
</tr>
<tr>
<td>You may see reduced swelling after the first treatment. It is very important to start the treatment proximal to the ankle in cases with swelling. Pain should decrease in 1-3 treatments.</td>
<td>Pain should decrease in 2-4 treatments.</td>
</tr>
<tr>
<td><strong>RECOMMENDED TREATMENT PLAN:</strong></td>
<td></td>
</tr>
<tr>
<td>· Every day for 3 days.</td>
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</tr>
</tbody>
</table>

**HELPFUL TIPS:**

During all treatments the handpiece will be contacting the skin with the exception of open wounds. Get feedback from patient in regards to comfort level, heat tolerance, and sensitivity. If patient experiences increased symptoms or no change at all in the first 3-5 visits, reduce wattage by 30%. If after 3-5 visits at reduced wattage, the condition is still not responding, incrementally increase wattage above the preset protocol for 3-5 visits. Always locate the most sensitive or painful trigger point before moving onto secondary or tertiary points. This will enable you to address the areas producing most discomfort to the patient. (Refer to page 22 “Reduce Wattage”).
GLOSSARY OF TERMS

Absorption: Transformation of radiant energy to a different form of energy by the action of matter, depending on temperature and wavelength. (12-20)

Accessible Emission Level: The magnitude of accessible laser (or collateral) radiation of a specific wavelength or emission duration at a particular point. Also means radiation to which human access is possible in accordance with the definitions of the laser’s hazard classification. (25-27)

Accessible Emission Limit (AEL): The maximum accessible emission level permitted within a particular class of lasers. In ANSI Z-136.1, AEL is determined as the product of Accessible Emission Level Maximum Permissible Exposure (MPE) limit and the area of the limiting aperture (7mm for visible and near infrared lasers). (25-27)

Aiming Beam: A laser (or other light source) which is used as a guide light. Used coaxially with infrared or other invisible light, an aiming beam may also be a reduced level of the actual laser used for surgery or for other applications.

Angstrom Unit: A unit of measurement of wavelength equal to 10^-10 meter, 0.1 nanometers, or 10^-4 micrometers. No longer widely used or recognized in the SI system of units.

Aperture: Any opening through which laser radiation can pass. A variable aperture has the capability to produce a variable output laser spot size. The K-Laser® Device’s Zoom Handpiece is an example of a variable aperture. (24)

Arndt-Schulz Law: Refers to “U” shaped dose response curves for external agents: below a threshold there is no effect, a small amount of something has small effect, a moderate amount has a large effect, and a large amount has either no effect or an adverse effect. This “law” was originally formulated in the world of pharmacology, has come in and out of favor several times, and now serves as one of the foundations of homeopathy. But, it is crucial to remember that this is not a “law” at all, nor is it based on fundamental principles or cellular processes, and so to claim that more than X amount of radiation is inhibitory because the Arndt-Schultz law says so, is completely unfounded.

Average Power: The total energy (in Joules) imparted during a laser session divided by the total time (in seconds) of the exposure duration. Average power is measured in Watts, and is displayed on the K-Laser® Device as “W”. (34-37, 47)

Aversion Response: Movement of the eye, eyelid or head to avoid an exposure to a noxious stimulant or a bright light. It can occur within 0.25 seconds, including the blink reflex time. (ANSI) (25-27)

Beam: A collection of rays that may be parallel, convergent, or divergent.

Beam Divergence: The tendency of a laser beam to expand in diameter as it moves away from the source, measured in milliradians (mrad) at specified points. (24)
GLOSSARY OF TERMS

Biomodulation: The process of changing the natural biochemical response of a cell or tissue within the normal range of its function, stimulating the cell's innate metabolic capacity to respond to a stimulus. A cell can heal itself by this stimulation mechanism. (12-20, 39-40)

Chromophore: Part of a molecule responsible for its color. In biological molecules that serve to capture or detect light energy, the chromophore is the component that causes a conformational change of the molecule when hit by light. The primary chromophore involved in laser therapy is cytochrome-C Oxidase, the rate-limiting enzyme in the electron transport system. (12-20, 39-40)

Class 3A Lasers: Generally have an output of 0.005 Watts (5 milliwatts). Class 3A lasers can cause eye injury and have wavelengths in the visible range only. It takes 3\(\frac{1}{3}\) minutes for a 5mW laser to produce one Joule of energy. (Examples: Erchonia, laser pointer) (8, 25-27)

Class 3B lasers: May have an output power of up to 0.5 watts (500mW) per emitter. There may be multiple emitters contained in one applicator, thus allowing total powers in excess of Class 3B limits without actually requiring the device to be reclassified as Class 4. Class 3B lasers are capable of injuring eyes from direct viewing or reflection of the beam. Class 3B lasers are used as therapeutic devices and are generally safe for skin exposure. However, patients may feel discomfort with darker skin or if areas of dark pigmentation (birthmarks, tattoos) are irradiated. (Examples: Chattanooga, Apollo) (8, 25-27)

Class 4 lasers: The output power of a single emitter exceeds 500mW. Class 4 lasers are capable of causing both optical injury and thermal injury to the skin, but in the hands of a trained clinician, class 4 therapy lasers are a very safe but powerful and effective therapeutic tool. In the laser classification scheme, Class 4 is the highest, so all lasers above 500mW are Class 4. (Example: K-Laser® K-CUBE SERIES™) (8, 25-27)

Coherence: A property of monochromatic electromagnetic waves that are synchronized so that all 'crests' and 'troughs' are aligned. Laser light has the special quality of coherence. Light produced by light emitting diodes (LEDs) or super-luminous diodes (SLDs) is not coherent. (10)

Coherence Length: The distance over which energy in two separate waves remain in phase. (10)

Cold Laser: A nickname given to early low-level lasers that were used in therapy. In contrast with high-powered lasers at the time that were used for surgical procedures, hair removal or cosmetic procedures, these low-level lasers did not impart a thermal effect to the skin. Their extremely low power earned the nickname "cold". This term could also be applied to the K-Laser® Device; it is 'cold' in the sense that the intended outcome is pain relief and tissue stimulation, and not surgical, cutting or hair removal. (8, 25-27)

Collimation: A property of light commonly associated with lasers and accomplished with focusing lenses to prevent the beam from diverging. True laser systems focus all of their energy in one direction in a very concentrated line. Diode lasers do not emit collimated light, and therefore collimation into a beam requires a collimating lens. (24)
GLOSSARY OF TERMS

**Continuous Wave (CW) Emission:** Energy emitted in a continuous manner, as in a light that is constantly 'on'. In continuous wave emission the average power is equal to the peak power. (5, 34-38, 45-46)

**Cytochrome c Oxidase:** A large protein complex found in the walls of the mitochondria. It is the terminal enzyme in the respiratory electron transport chain. It has recently been discovered to be the chromophore responsible for the up regulation of ATP output and NO release as a result of laser therapy. (12-20, 39-40)

**Divergence:** The increase in diameter of the laser beam with propagation distance from the exit aperture. (ANSI) (24-27)

**Dosage:** (See Energy Density)

**Duty Cycle:** For modulated laser emission, it is the fraction of time that the laser is 'on' and is usually expressed as a percentage. When operating in Frequency Modulated (Hz) mode, the K-Laser® Device is at a 50% duty cycle which means over any given period of time, the laser light is “on” half the time and “off” half the time. (34, 37)

**Electromagnetic Radiation:** The propagation of varying electric and magnetic fields through space at the velocity of light. (8, 10, 25)

**Electromagnetic Spectrum:** The electromagnetic spectrum is a continuum of all electromagnetic waves arranged according to frequency and wavelength. The sun, earth, and other bodies radiate electromagnetic energy of varying wavelengths. Light is a particular type of electromagnetic radiation that can be seen and sensed by the human eye, but this energy exists at a wide range of wavelengths. (8, 10, 12-20, 39-40)

**Energy:** The capacity for doing work, and is measured in Joules (J). Can be calculated by multiplying power (watts) by time(seconds), \( E = P \times t \).

**Energy Density:** The total energy in Joules is divided by the total area treated, in cm\(^2\). A measure of the amount of energy being delivered to a particular area on a surface, stated in Joules per square centimeter (J/cm\(^2\)). The energy density given during a Class IV laser therapy treatment is typically between 2 and 10 J/cm\(^2\). Also referred to as radiant exposure and dosage. (17-20, 28-33)

**Frequency:** In relation to light and lasers, the term “frequency” is used in two different ways—be aware of the distinction.

1. **Frequency Modulation** can also be used to describe the pulse repetition rate of a pulsed or super-pulsed laser. It gives the number of pulses per second (the number of flashes ‘on’ and ‘off’), and is measured in Hertz, Hz. The K-Laser® Device has a pulse range from 2 to 20,000Hz. (12-20, 39-40)

2. The frequency of light is inversely proportional to its wavelength, and is dependent upon the energy value of the individual photons being emitted. The shorter the wavelength of light, the higher its frequency and the higher the energy of the photons. Ultraviolet light has a higher frequency than infrared light. Ultraviolet photons carry much more energy than infrared photons; and ultraviolet light can ionize molecules, whereas infrared light cannot. (25)
GLOSSARY OF TERMS

Grothus-Draper Law: "Only that light which is absorbed by a system can bring about a photochemical change." It was first proposed in 1817 by Theodor Grothus and John W. Draper, and is also called First Law of Photobiomodulation or the Principle of Photochemical Activation. Cells must "see the light" to be affected by laser therapy, there must be interaction between photons and target cells for photobiomodulation to occur.

Infrared radiation: Non-ionizing electromagnetic radiation within the wavelength band from 700 to 10,600nm. (12-20, 25, 39-40)

Ionizing radiation: Radiation commonly associated with X-ray or other high energy electro-magnetic radiation that will cause DNA damage with no direct, immediate thermal effect. By contrast, therapy lasers that use near-infrared light produce non-ionizing radiation. (8, 10, 12)

Irradiance (E): (See Power Density)

Joule: A fundamental unit of energy. Joule = Watt x Second

Laser: An acronym for light amplification by stimulated emission of radiation. A cavity with mirrors at the ends, filled with material such as crystal, glass, liquid, gas, or dye. A device that produces an intense beam of light with the unique properties of coherency, collimation, and mono-chromaticity. (10-11)

Laser Medium: Also known as active medium. Material used to emit laser light and for which the laser is named. (10-11)

Laser Safety Officer: The laser safety officer (LSO) is the person responsible for the laser safety program in the facility. This individual has the training and experience to administer said program. (ANSI) (25-27)

Laser Diode: A semiconducting device that emits monochromatic non-ionizing radiation by a process of stimulated emission. A laser beam has a number of unique properties, such as coherence, polarization and directionality, and the beam is divergent unless manipulated with additional optical devices such as lenses. (10-11)

Light Amplification by Stimulated Emission of Radiation (LASER): The production of electromagnetic radiation via the process by which an electron, perturbed by a photon having the correct energy, may drop to a lower energy level resulting in the creation of another photon. The second photon is in phase spatially and temporally with the first, which produces coherent light. (10-11)

Light Emitting Diode (LED): A semiconductor light source that emits non-coherent, narrowband, non-ionizing radiation. Some light therapy devices, LEDs are used in multiple-emitter clusters. (See Coherence)

Low-Level Laser: A term used to describe therapeutic lasers that do not cut, cauterize or destroy human tissue. (8, 25-27)
GLOSSARY OF TERMS

Low-Level Laser Therapy (LLLT): An emerging medical and veterinary technique in which exposure to low-level laser light stimulates cellular function leading to beneficial clinical effects; also known as photobiomodulation, cold laser therapy, and laser biostimulation. Even though some warming is felt with K-Laser® Treatment, it is still considered low-level laser therapy. (8, 25-27)

Maximum Permissible Exposure (MPE): The level of laser radiation to which a person may be exposed without hazardous effects or adverse biological changes in the eye or skin. (ANSI) (25-27)

Monochromatic: Monochromatic light is of a single wavelength (i.e. one specific color) though in practice it can refer to light of a narrow wavelength range. Because the wavelength of laser light determines its effect on tissue, the monochromatic property of laser light allows energy to be delivered to specific tissues in specific ways. (10)

Nanometer (nm): Unit of measurement for wavelengths of light. One billionth of a meter (1 x 10^-9m). Visible light has wavelengths from 400 to 700 nm.

Nd:YAG Laser: A solid-state laser that uses a rod of yttrium aluminum garnet (YAG) doped with neodymium to serve as the lasing medium.

Nominal Hazard Zone (NHZ): The space within which the level of direct, reflected or scattered radiation during normal operation exceeds the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the appropriate MPE level. (ANSI) (25-27)

Nominal Ocular Hazard Distance (NOHD): The distance along the axis of the unobstructed beam from the laser to the human eye beyond which the irradiance or radiant exposure during normal operation is not expected to exceed the applicable MPE. (ANSI) (25-27)

Optical Density: A logarithmic expression for the attenuation produced by an attenuating medium, such as an eye protection filter. (25-27)

Optical Fiber: A filament of quartz or other optical material capable of transmitting light along its length by internal reflection and emitting it at the end.

Output Power: The energy per second measured in Watts emitted from the laser in the form of coherent light.

Penetration: Penetration refers to the distance an energy wave travels into the tissue before it is absorbed or dissipated as heat or molecular vibration. Penetration of laser light is dependent on many factors, but the primary determinant is wavelength. Lower wavelengths are absorbed by hemoglobin and melanin, and higher wavelengths are absorbed by water in the tissues. (See Therapeutic Window) (17-20)

Photobiomodulation: (See Low-level laser therapy). Photobiomodulation is the term that was agreed upon by the laser therapy community at the North American Association of Laser Therapy (NAALT) meeting in June 2003. When biomodulation occurs from a photon transferring its energy to a chromophore it is referred to as photobiomodulation. (12-20, 39-40)
GLOSSARY OF TERMS

Photon: In quantum theory, the elemental unit of light, having both wave and particle behavior. It has motion but no mass or charge. The photon energy (E) is inversely proportional to the EM wave wavelength (λ) by the relationship: E=hc/λ, where h is Planck's constant (6.63 x 10^-34 Joule-sec); c is the speed of light in the medium (3x108 meters per second in a vacuum); and λ is expressed in meters. (10)

Power: The rate at which energy is emitted, transferred or received. The standard international unit of power is the Watt. One Watt is equal to one Joule per second, W = J/s.

Power Density: A measure of the amount of radiation being delivered to a particular area on a surface, stated in watts per square centimeter (W/cm²). A consistent power density correlates into more consistent clinical results. K-Laser treatments have a power density around 2 W/cm². Also known as irradiance. (11,13, 19, 22, 29)

Pulsed Lasers: In the pulsed mode of operation, the output of a laser varies with respect to time, typically taking the form of alternating 'on' and 'off' periods (see Duty Cycle). From research we know that various pulse rates elicit different physiological responses from the tissues. Low pulse rates are analgesic, mid-range rates are biostimulatory, higher rates are anti-inflammatory and highest pulse rates are antimicrobial in nature. The body's sensitivity to any steady stimulus diminishes over time. Varying the pulse rate helps to ensure a better response.

Pulsing: (See Frequency Modulation)

Radiance: Brightness. The radiant power per unit solid angle and per unit area of a radiating surface. (34-37)

Radiant Energy (Q): Energy in the form of electromagnetic radiation, usually expressed in Joules.

Radiant Exposure (H): The total energy per unit area incident upon a given surface. Used to express exposure to pulsed laser radiation in units of J/cm².

Radiant Flux: Also known as radiant power. The time rate of flow of radiant energy. Units: Watts. (1 Watt = 1 Joule-per-second). The rate of emission of transmission of radiant energy.

Retracing: The conversion of condition from chronic back to acute. From time to time, a patient will experience an increase in pain following treatment. It is NOT an adverse reaction, but indicates that the laser treatment is working. Patients will frequently observe improvement once this pain subsides within 24-hours. This is a normal process. Always advise the patient in advance of the possibility of the pain response or they may assume that the laser has caused them harm.

Stimulated Emission: When an atom, ion or molecule capable of lasing is excited to a higher energy level by an electric charge or other means, it will spontaneously emit a photon as it decays to the normal ground state. If that photon passes near another atom of the same frequency, the second atom will be stimulated to emit a photon. (10)
GLOSSARY OF TERMS

Super-Luminous Light Emitting Diode (SLD): Super-luminous light emitting diodes generally emit at a lower optical power than LED’s, but in a narrower spectral range. Radiation emitted by SLDs has a much shorter coherence length than that produced by lasers. Despite the widespread use of the term by manufacturers, SLDs are NOT used in multi-emitter clusters as they are too expensive and convey no greater therapeutic benefit than LED’s. (See Coherence)

SuperPulsed Emission: Energy emitted in a single pulse, or train of pulses, in which the duration of each pulse is less than 25 milliseconds. The average power of a super-pulsed emission is calculated by multiplying the peak power, pulse duration and frequency of pulsation. The K-Laser® SuperPulse has a peak power of 15 Watts, and when pulsing 20,000 times per second has an average power output of 6 Watts. (34-37)

Therapeutic Window: Therapeutic laser light is primarily absorbed by the hemoglobin, melanin and water in human tissue. These three components each have a unique absorption curve that is dependent on the wavelength of the laser light. Hemoglobin and Melanin absorb more at the shorter wavelengths, between 200-700 nanometers. Water absorbs more of the laser light above approximately 960 nanometers. The three absorption curves have a relative minimum around 800 nanometers. Laser light in the range of 780nm to 920nm penetrates the deepest into human tissue. (8, 10, 12-20, 39-40)

Thermal Relaxation Time: The time to dissipate the heat absorbed during a laser pulse. (34-37)

Ultraviolet (UV) Radiation: Electromagnetic radiation with wavelengths between soft X-rays and visible violet light, often broken down into UV-A (315-400nm), UV-B (280-315nm), and UV-C (100-280nm). (8,10, 25)

Visible Radiation: Non-ionizing electromagnetic radiation within the wavelength band from 400nm to 700nm that can be seen by the human eye. (8,10, 25)

Watt: The unit of power or radiant flux. Watt = Joule per second

Wavelength: The distance between two successive points on a periodic wave in the same phase. Due to the short wavelengths of light and infrared radiation, this is often expressed in nanometers. For laser light, wavelength is the prime determinant of tissue penetration. (9,11, 12-20, 39-40)


