Laser Therapy: What Makes It Tick?

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THE INCORPORATION OF THERAPEUTIC LASER ENERGY as a treatment modality in veterinary medicine is here to stay. Understanding how to provide the correct administration of this energy form to produce optimal treatment results in our patients is the ultimate goal.

Unlike surgical lasers (10,600nm CO2 and contact 980nm diode) that have their full impact in the first 1 to 5mm of tissue, therapy lasers transmit their energy much deeper into tissue (4-5 cm). The penetration of this energy is dependant upon the wavelength transmission and not the power applied. This is the key critical factor that is misunderstood by many veterinarians currently promoting therapeutic laser energy. Other very important factors that allow for maximal positive therapeutic effect include: total time of administration, duration of energy administration, mode of wavelength release from the device (continuous, chopped, pulse or synchronous) and total energy to be delivered to the tissue (this is not the power output at the surface, rather, it is the total dose of energy that reaches the targeted cells). Getting all these parameters correct produces optimal positive therapeutic tissue effect. If you do not have the correct combination of parameters when applying therapeutic laser energy into the tissue, you will produce no effect, excellent effect, or adverse effect, dependant on the tissue being targeted. The difference between a positive and negative effect can be as small as a factor of 10 or less when changing parameters.

It is this ability of varying diode wavelengths to transmit energy 4-5 cm into tissue that gives therapeutic lasers such great potential to stimulate positive change within damaged or diseased tissue. Appropriately transmitting diode wavelengths improve damaged cellular organelles and membranes, increase cellular respiration (ATP production), alter pain perception, modify pain receptor response, reduce pain, increase endorphin production and limit intra- and extra-cellular edema. It is important to remember that while therapeutic laser energy penetrates much more deeply into tissues, about 60 to 80% of the energy is absorbed in the top 1-2cm of tissue during the transmission, with most of the absorption occurring in the first 1 cm (Figure 1, Lambert-Beer Law). This is why the wavelength used is so much more important that the Power (W) applied initially. In the much more confined dimensions of CO2 laser/tissue interaction, the greater the surface Power (W) the more effective the vaporization. Clinicians inappropriately apply this rational to therapeutic laser/tissue interaction. It is critically important to realize that raising Power (W) levels at the therapeutic laser probe/surface tissue interface does not translate linearly to direct energy increase at the deeper tissue target site.

The Lambert-Beer Law shows that Power (W) is non-linearly absorbed. This is caused by a variety of chromophores (water, hemoglobin, oxy-hemoglobin and melanin) that absorb photonic energy in the first 2 cm of tissue. Thus, it is far more important to select the appropriate wavelength to effectively transmit laser energy to deeper target tissues than increase total power at the surface. The absorption of this energy in the surface tissues is mostly converted to photo-thermal energy effect. This effect is seen more commonly observed with 970nm-990nm wavelengths due to their relatively shallow penetration depth (Figure 2a) and higher absorption coefficient of water (Figure 2b). We generally equate warming of tissue with a comforting or calming effect to tissue. But just like applying heating pads at too high a temperature can damage or destroy cells, photo-thermal energy release may raise cellular temperatures above 45° C. At this temperature cellular metabolism slows and enzymatic functions decay. Continued increased power levels can cause rupture of protein bonds and fragmentation of cohesive molecular forces ultimately causing cellular damage or cellular death.

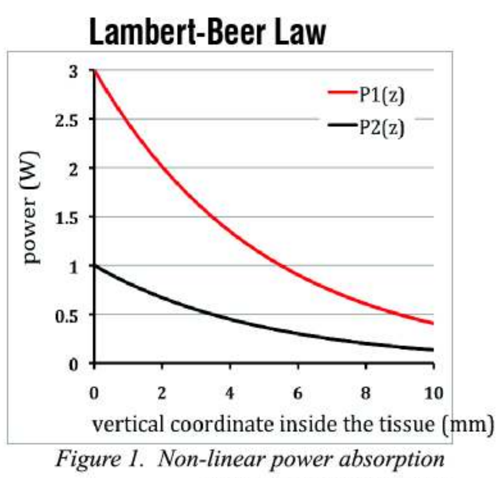

Figure 1. Non-linear power absorption in the first 1 cm of tissue

Since depth of wavelength penetration is a better parameter to provide therapeutic laser energy to deeper tissues than total power, the selection of the 808nm and 905nm near infrared wavelengths are recommended to maximize energy delivery to deeper target cells (Figure 2a and 2b).

The mode of laser energy administration also has been shown to play a key role in maximizing tissue response. Laser energy can be administered in a continuous, mechanically chopped, pulsed or synchronous release fashion. Multiple studies have shown the synchronous release of a combination of 808nm and 905nm wavelengths can produce optimal uniformity in total energy dispersion into the target tissue (Figure 3: Synchronous energy release of 808nm and 905nm diode energy).

Wavelength	Penetration depth
Visible Red (630-700 nm)	0.5-1 cm
Near Infrared (700-800 nm)	2-3 cm
Near Infrared (800-970 nm)	3-4 cm
Near Infrared (970-990 nm)	1-2 cm
Near Infrared (990-1200 nm)	4-5 cm

Figure 2a: Near Infrared tissue penetration

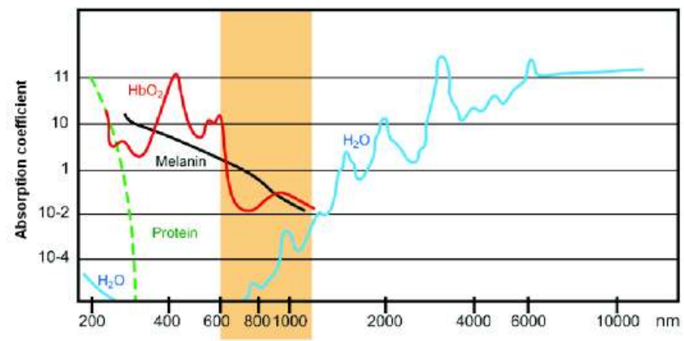

Figure 2b: Absorption coefficients of top chromophores

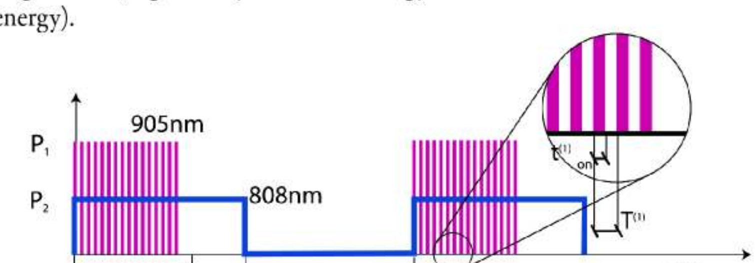

Figure 3: Synchronous energy release of 808nm and 905nm diode energy

The intra and extracellular effects on these deeper tissues from therapy laser energy in these wavelength ranges is seen as a photochemical and photomechanical transfer of energy into cellular chromophores in the cells and tissues. Photochemical and photomechanical effects associated with the 808nm wavelength are most responsible for reduction in pro-inflammatory molecules, anti-edema, and bio-stimulation effects. Photochemical and photomechanical effects associated with the 905nm wavelength are most responsible for enhanced analgesic potential, enhancing lymphatic peristalsis and realignment of damaged collagen fibers and connective tissues.

Equally important is the fact that current research has shown that therapy laser energy has a biphasic dose response associated with total time of administration, mode of wavelength administration and total energy administered in the target tissue. Not enough produces no effect and too much produces negative effects (Figure 4, Biphasic effect).

Dose Dependence and Dose Rate Effects: Biphasic Curve

- **Therapeutic laser energy appears to follow a biphasic dose dependant curve**
- **Arndt-Schulz Law: Weak stimuli slightly accelerate vital activity; stronger stimuli raise it further, but a peak is reached and even stronger stimuli suppresses acceleration of vital activity.**

Figure 4: Biphasic Effect

Ongoing basic research and multi-center second and third tier quality clinical studies are providing increasing knowledge of what the optimal parameters discussed in this article for therapeutic laser energy administration will be. There is much more to learn, but the evidence is compelling and exciting. We have sufficient information from over 30 years of human and animal clinical treatments to have a general consideration of the guidelines for wavelength, time and fluence levels we should follow.