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Physics for Chiropractors

Calculating the Energy Density of a Therapy Laser

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If you are planning on adding a therapeutic laser to your practice, you have plenty of unanswered questions and a lot of decisions to make. On the clinical level, you want to know how it works: which conditions it will benefit and how to incorporate laser therapy with your existing chiropractic techniques and modalities. On the business level, you need to determine how much to invest, what return on investment you can expect and how to adjust office flow to accommodate this exciting new modality.

Before tackling those complicated issues, it would help to examine the basics. Here are some key physics concepts that you must understand when buying a therapy laser: power and power density, wavelength, mode of delivery (continuous wave, pulsed and superpulsed), energy and energy density.

This article will help you calculate the energy density of a therapy laser. The pertinent physical quantities and associated units are as follows:

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:

Power = Energy/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):

Energy = Power x Time = 0.1W x 180 s = 18 J

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

Energy Density = Energy/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.

Quantity	**Unit of Measurement (Abbreviation)**
Power	Watts (W)
Area	Square Centimeters (cm2)
Time	Seconds (s)
Energy	Joules (J)
Energy Density	J/cm2

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*.[1] 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.

Area	Energy Density of 18 J
100 cm2	0.18 J/cm2
5.5 cm2	3.3 J/cm2
0.4 cm2	45 J/cm2

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 calls 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 physics-challenged chiropractors calculate the energy density of a therapy laser. Further discussion of appropriate energy densities will be left for another column.

References

1. Tuner J, Hode L. *Laser Therapy: Clinical Practice and Scientific Background*. Grängesberg, Sweden: Prima Books, p. 70.
2. *Ibid*, p. 72.
3. *Ibid*, p. 73.

Dr. Phil Harrington graduated from Iowa State University with a BS in physics, taught high-school math and physics for three years, and graduated from Palmer College in 1996. While completing his prerequisites to enter Palmer, he tutored pre-chiropractic students in physics. He was in private practice for 10 years and is now senior VP of K-LaserUSA. He may be reached at pharrington@k-laserusa.com.