Laser Therapy in Companion Animals

What It Is, How It Works, & When It Benefits Patients

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The use of laser therapy in small animal patients has been on the rise over the last several years. More and more information is becoming available about the different uses and benefits of lasers.

Unfortunately, from an evidence-based medicine perspective, there is very little information in the veterinary literature. Therefore, current thoughts regarding therapeutic benefits of laser therapy are mainly derived from human and laboratory studies and subjective experiences, that is, anecdotal evidence. Lack of objective, evidence-based observations and studies makes it difficult to evaluate the true therapeutic value of lasers.

The intent of this article is to:

1. Introduce the basic properties of lasers
2. Explain their proposed mechanism of action, particularly for rehabilitation
3. Review several treatment protocols for various conditions that have been derived from other sources.[1]

Each reader is encouraged to seek evidence-based studies to determine whether your patients can benefit from laser treatment, not only for rehabilitation, but for other uses as well.[1]

WHAT IS LASER THERAPY?

The light produced by a laser, which is an acronym for *light amplification by stimulated emission of radiation*, has the ability to be absorbed by tissues, creating both photothermal and photochemical reactions that create a therapeutic benefit.

The initial form for rehabilitation purposes used low-level laser therapy (LLLT)[1] as opposed to the high power used in surgical lasers, which apply heat to cause thermal destruction of cells and tissues. New therapeutic lasers have recently emerged that deliver more power than LLLT, but less power than surgical lasers.

For rehabilitation, exact interaction between lasers and tissues is not completely understood. However, lasers have been shown to modulate cellular functions. For example, LLLT helps modulate various biologic processes that enhance:

- Muscle regeneration[2]
- Wound healing
- Joint healing[3]
- Control of acute and chronic pain.[4]

HOW DO LASERS WORK?

Lasers are created by activating electrons to an excited state.[5] Once the electron moves from an excited state to its ground state, release of photons occurs, and they form a beam of light.

> Many types of lasers are available for purposes ranging from industrial to medical; in veterinary medicine, they are most commonly used for surgery, rehabilitative therapy, management of chronic conditions, and pain control.

Laser Light Properties

Lasers consist of a monochromatic, coherent, collimated light; these properties help distinguish between laser light and light generated by other sources, such as sunlight.

Monochromatic

- Essentially, when light is emitted from the unit, it is a single wavelength, unlike natural light, which is emitted at varying wavelengths.
- This property allows production of light targeted for absorption by a specific tissue and for a specific use.
- Depending on the unit, several wavelength options may be available for different therapeutic uses.

Coherent & Collimated

- Coherence is characterized by photons that emerge from the unit and travel in the same phase and direction.
- Collimation describes light that is emitted from the unit and does not diverge.
- Coherence and collimation allow the laser to penetrate

the skin, treating only a small area of the body, while minimizing/avoiding unwanted effects to other tissues, such as heating and/or damaging the skin.[1]

Tissue Interaction with Lasers

Light Reaction

Tissues interact with lasers in varying ways, allowing light to be reflected, scattered, transmitted, or absorbed.

- **Reflection** of photons takes place at the epidermis; reflected photons not only lack clinical effect, but can also be responsible for tissue damage (eg, to the eyes).
- **Scattering** occurs once the photons penetrate the tissue. Each time the scattered photons strike an object outside the target tissue, the amount of photon energy is reduced.
- **Transmitted** photons also lack clinical effect because they pass through the tissue without being absorbed.
- **Absorption** of photons by the target tissue realizes the therapeutic benefit of lasers. See **The Benefits of Absorbed Photons**.

Wavelength

Wavelengths are typically measured in nanometers (nm). Wavelength is important when determining the biological effect of lasers on tissues. Tissues, such as melanin and proteins, absorb ultraviolet light (100–400 nm). Light on the other end of the spectrum (1400–10,000 nm) is absorbed by water. Therefore, optimum wavelength ranges of 600 to 1200 nm—which minimize scatter and maximize absorption—are recommended for tissue penetration (**Figure 1**).

Power

The power density or intensity indicates the amount of power in a given surface area, while the spot size of the laser indicates the surface area size that can be treated when the laser is held stationary. Lasers with larger spot areas have a more homogeneous passage of the photons with less scatter.

The *energy* of the laser characterizes the power emitted over time, measured in joules. Frequently, energy *density* is used to report dosage of the laser in joules per cm^2 (J/cm^2).

Continuous or Pulsed Emission of Photons

Photons can be emitted either continuously or by pulse.

- Continuous emission implies that radiation is emitted at a constant power for the entire duration of use.
- Pulsed therapy implies that radiation is delivered in cycles over the entire duration of use, with time spent one of 2 ways: radiation emitted or no radiation emitted.

Currently, there is debate for superiority of continuous versus pulsed therapy. Some have suggested that there is no difference,[1,6] while others have shown that pulsed therapy may be more effective.[7]

> **THE BENEFITS OF ABSORBED PHOTONS**
>
> A chromophore is responsible for a molecule's color and, in biologic molecules, undergoes a conformational change when hit by a light, such as a laser. This change in the chromophore excites cells and can possibly alter, or speed up, cellular reactions.
>
> Commonly noted chromophores include hemoglobin, water, melanin, proteins, and amino acids.[1] The thought process is that these compounds—when exposed to laser light—cause alteration of cellular functions, allowing increased healing and/or recruitment of secondary mediators to facilitate healing.

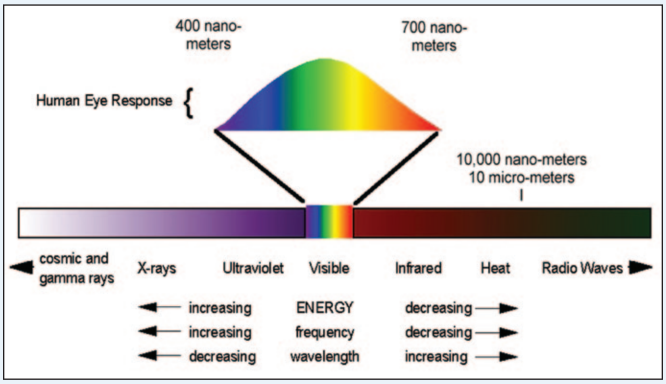


Figure 1. *Electromagnetic spectrum: Most lasers for therapeutic uses fall in the infrared or near red portion.*

WHEN SHOULD LASER THERAPY BE USED?

While veterinary studies are sparse, currently, most studies evaluating laser therapy focus on wound healing and pain management.

From a biologic perspective, photons absorbed through cellular pathways allow production of adenosine triphosphate (ATP). This process is similar to photosynthesis in plants: light is absorbed and converted into chemical energy (ATP) by reduction of CO_2 to useful organic compounds, such as glucose.

ATP not only alters cellular metabolism, but also acts as a cell-signaling molecule[8] and/or neurotransmitter.

- ATP's role as a neurotransmitter helps explain some of the **pain modulation** effects of lasers.[1]
- Due to enhanced cellular metabolism, lasers potentially **accelerate tissue repair** and **cell growth**.
- Additional effects of laser therapy are **stimulation of stem cells**[8] and **anti-inflammatory effects** that decrease prostaglandin E2 (PGE2) and cyclooxygenase-2 (COX-2).[9]

> **KEY RECOMMENDATIONS**
>
> » Hold the laser 90 degrees to the skin surface to **minimize reflection** of the laser.
>
> » To help **negate the scatter effect**, use wavelengths in the range of 600 to 1200 nm, which pass deeper into tissue and minimize this effect, and apply the laser directly to the skin.
>
> » Use lasers with larger spot areas, which **allow more homogeneous passage of photons, less scatter, and greater treatment area.**

Further, in-depth discussion of biochemical reactions is beyond this article's scope.

Osteoarthritis

The anti-inflammatory effects of laser therapy are considered to be due to reduced levels of PGE2 and COX-2.[10] In rat osteoarthritis (OA) models, laser therapy (1) reduced edema within the joint by 23%, (2) decreased vascular permeability in the periarticular tissue by 24%, and (3) decreased pain by 59%.[11]

Some subjective studies in humans with OA have shown (1) improved quality of life,[2] (2) reduced pain, and (3) increased analgesic and microcirculatory effects.[12] However, there have been conflicting reports in human medicine that reveal no benefits of laser therapy.[1]

Therefore, it has been suggested that individual results may depend on:

- Type and extent of disease
- Wavelength
- Method of application
- Dosage
- Site
- Duration of treatment.

Tendon & Ligament Conditions

An experimental study in rats with calcaneal lesions treated with laser therapy revealed improved collagen organization in the treatment group compared with the control group, with 5-day treatment providing optimal response.[13]

In humans, results are conflicted, with about 50% of studies showing a positive effect and 50% showing no effect. In human ligamentous injuries, laser therapy has shown improved tensile strength and stiffness compared with controls.[14]

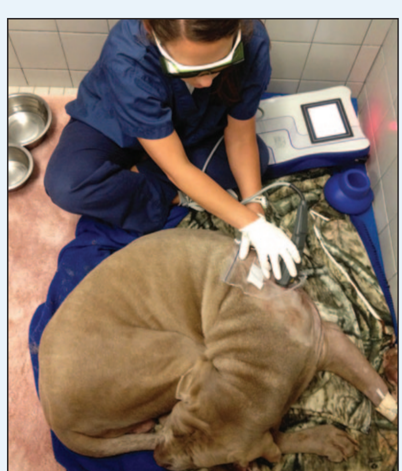
Pain Management

The exact mechanisms remain unknown, but it is thought that laser therapy has the potential to influence pain perception by direct and indirect actions on superficial nociceptors and modulation of inflammation. Furthermore, repeated application of laser therapy may decrease central sensitization.

Laser effects appear to be mainly inhibitory for pain receptors, and sensory nerves are more commonly affected.[1] The superficial location of A delta and C nerve fibers, along with neurons that supply the vasculature for vasoconstriction and vasodilation, allows laser penetration.

Unfortunately, use of lasers for pain

***Figure 2.** An example of a Class 3 laser.* Courtesy Ruby Lynn Carter, LVT, CCRT, Mississippi State University



***Figures 3 and 4.** Eye protection should always be worn when the laser is in use; this includes any individuals in the room as well as the patients, if they will tolerate it.* Courtesy Artise Stewart, DVM, CCRP, Charleston Veterinary Referral Center, Charleston, SC

LASER CLASSIFICATION

Laser classification is based on wavelength and maximum output in power or energy. Current classifications consist of class 1 through 4.

Class 1 lasers are very mild and safe. They include lasers used in everyday life; for example, those used in equipment that implements bar code scanning, such as cash registers at the supermarket.

Class 2 lasers are in the visible light spectrum (400–700 nm). Some therapeutic lasers and laser pointers fall into this class. Damage can occur if the laser is directed into the eye for prolonged periods.

Class 3 lasers (**Figure 2**) include the commonly used therapeutic lasers. These lasers are further subdivided into:

- **Class 3B lasers** are either continuous in the visible to infrared spectrum, or pulsed in the visible light spectrum.
- **Class 3R lasers** are continuous within the visible light spectrum and have less power than Class 3B lasers.

Class 4 lasers are the strongest lasers, and mostly include surgical lasers. They have the ability to permanently damage the eyes or burn the skin.

KEY RECOMMENDATIONS

» With Class 3 lasers (3B and 3R), eye protection must be used at all times (**Figures 3 and 4**).

» With Class 4 lasers, eye protection must be worn and the clinician must use great care to control the beam.[1]

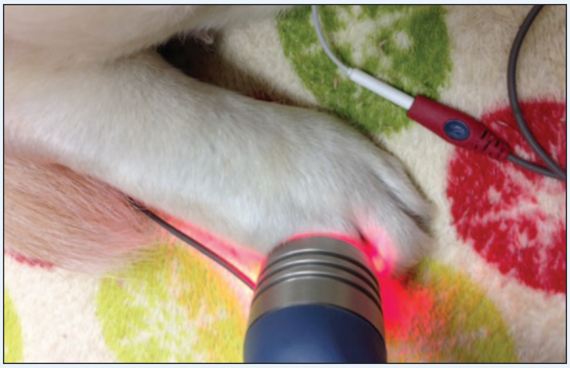


Figure 5. Note the perpendicular placement of the probe on the skin, which minimizes reflection of the laser. Courtesy Ruby Lynn Carter, LVT, CCRT, Mississippi State University

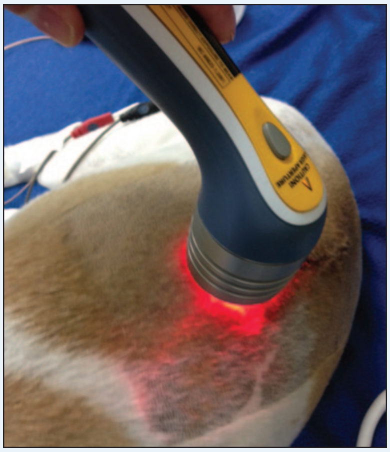


Figure 6. Application of the laser directly to the skin to avoid scatter of the photons. Note, when treating open wounds, the laser should not be placed directly into the wound. Courtesy Ruby Lynn Carter, LVT, CCRT, Mississippi State University

management is purely speculative due to lack of studies. Hopefully, more evidence will become available in the future.

HOW IS LASER THERAPY APPLIED?

To treat small areas, laser therapy is administered using a handheld probe with a beam. The probe can be placed in:

- **Direct contact** with the skin, which minimizes reflection of photons (**Figure 5**)
- **A noncontact position**, in which the probe is held perpendicular to the treatment area and off the skin (**Figure 6**). Noncontact is recommended for wound treatment.

Dose & Duration

Currently, the most efficient way to determine the dose and time is to use available treatment tables[1] (**Table**).

Step-by-Step Application[1]

1. Clip the patient's hair, which maximizes the laser's effect because hair absorbs 50% to 90% of the light.
2. Measure the area to be treated.
3. Determine the treatment dose; in areas of darker skin, the dose should be increased by 25%.
4. Determine the total joules (J/cm^2) and treatment time needed. For example: If treating an area of 57 cm^2 (size of a playing card) with 10 J/cm^2, the total treatment is 600 J. If using a 10-W laser, the treatment time is 60 seconds.
5. Place safety goggles prior to using the laser: all personnel in the room should wear protective eye gear, and the patient's eyes should also be protected.
6. The laser should be pointed perpendicular to the treatment area.
7. Apply the laser treatment, moving slowly, over the area by using an overlapping grid technique to ensure the entire area is treated.

TABLE. Laser Therapy Treatment Guidelines

TREATMENT PURPOSE	RECOMMENDED THERAPY (once daily unless noted otherwise)
Analgesia for Pain *Associated with Joints*	• 4–6 J/cm^2 for *acute* pain • 4–8 J/cm^2 for *chronic* pain
Analgesia for Pain *Associated with Muscles*	• 2–4 J/cm^2 for *acute* pain • 4–8 J/cm^2 for *chronic* pain
Anti-inflammatory Therapy	• 1–6 J/cm^2 for *acute* inflammation • 4–8 J/cm^2 for *chronic* inflammation
Open Wound Therapy	• 2–6 J/cm^2 for *acute* wounds for 7–10 days • 2–8 J/cm^2 for *chronic* wounds once daily
Osteoarthritis Therapy	• 8–10 J/cm^2; treat along the joint lines (Refer elsewhere for treatment of particular joints[1])
Postoperative Wound Therapy	• 1–3 J/cm^2 once daily

Adapted from Millis DL, Saunders DG. Laser therapy in canine rehabilitation. In Millis DL, Levine D (eds): *Canine Rehabilitation and Physical Therapy*, 2nd ed. Philadelphia: Elsevier, 2014.

Precautions

Precautions with laser therapy generally involve protecting the eyes during treatment. Since the light is coherent, a small amount focused on the retina may cause permanent damage. Fortunately, visible light will generate a blink reflex to help protect the user; however, infrared lights are not visible so a blink reflex will not occur.

SUMMARY

In general, laser therapy is an emerging technique that appears to at least have subjective benefits. Potential areas where laser therapy can be incorporated are in wound healing, pain management, and rehabilitation for various conditions (eg, OA). As has been emphasized, evidence-based, peer-reviewed studies are lacking. The author encourages readers to pursue well-controlled studies that help document a proven benefit, along with appropriate doses and conditions that can be treated. ■

CONTRAINDICATIONS & PRECAUTIONS TO LASER THERAPY[1]

- Always use protective eye gear; furthermore, eyewear should be appropriate for the wavelength of the laser being used.
- Never direct the laser into the eye.
- Use caution around metal surfaces as they can cause scatter of the laser light.
- Use caution with the following: pregnancy, open fontanels, around growth plates, malignancies, and photosensitive areas of the skin.
- Darker skin and hair can absorb the laser light and cause excessive heating of the skin.

ATP = adenosine triphosphate; COX-2 = cyclooxygenase-2; laser = light amplification by stimulated emission of radiation; LLLT = low-level laser therapy; nm = nanometer; OA = osteoarthritis; PGE2 = prostaglandin E2

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