INTEGRATIVE MEDICINE

# Laser Therapy for Treatment of Joint Disease in Dogs and Cats

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Photobiomodulation (PBMT), or laser therapy, is a rapidly growing treatment modality used for a variety of medical conditions in companion animals. PBMT is painless, noninvasive, and easily administered in a primary care setting.[1] Therapeutic laser devices are estimated to be used by 20% of all companion animal practices in North America.[1]

PBMT accelerates healing in a number of tissues, provides analgesia, and decreases inflammation through modulation of immune and inflammatory responses.[2] PBMT has been used in human and veterinary medicine to improve wound healing, treat snake bites, decrease pain and inflammation resulting from musculoskeletal conditions, improve neurologic function after trauma or injury, treat stomatitis and other oral inflammatory conditions, treat intraoperative and postoperative inflammation, and enhance healing of sport-related injuries.[1] The focus of this article, however, is on treatment of joint conditions in companion animals.

**TABLE 1 PBMT Glossary***

| TERM | DEFINITION |
|---|---|
| Coherent | Photons travel in the same phase in time and space |
| Collimated | Light divergence is minimized over a distance |
| Duty cycle | Percentage of total emission time to total treatment time in a pulsed laser |
| Fluence, J/cm$^2$ | Energy absorbed per area treated |
| Frequency, Hz | Number of waveforms in a defined time interval |
| Irradiance, W/cm$^2$ | Power intensity |
| Joule | Energy unit used to measure dose or rate of energy delivery |
| Monochromatic | Light of 1 wavelength |
| Spot size | Radius of the laser beam |
| Watt | Unit of power measured as 1 J/second |
| Wavelength, nm | Distance between crests of electromagnetic waves |

**Hz=hertz; J=joule; nm=nanometer; PBMT=photobiomodulation therapy; W=watt.*
*Adapted from a table published in "Photobiomodulation Therapy in Veterinary Medicine: A Review" in* Topics in Companion Animal Medicine.[7]

## WHAT IS PHOTOBIOMODULATION THERAPY?

Since its development, PBMT has been referred to by many names; terms such as cold laser, low-level laser therapy, phototherapy, and low-level light therapy appear in the literature and have caused confusion. Participants at a nomenclature consensus meeting recommended that the term photobiomodulation be adopted to mean "a form of light therapy that utilizes nonionizing forms of light sources, including lasers, light-emitting diodes (LEDs), and broadband light, in the visible and infrared spectrum."[3] PBMT is defined as a "therapeutic use of light, absorbed by the chromophores found in the body, to stimulate nonharmful and nonthermal reactions within the cell that result in a beneficial therapeutic outcome."[3] Although PBMT describes the effects of the therapeutic modality, the term LASER (commonly lowercased) is an acronym for light amplification by stimulated emission of radiation. Veterinary lasers can be used for either therapeutic or surgical applications, depending on the laser.

## HOW DOES PBMT WORK?

Studies have shown that PBMT alters the inflammatory response and affects cell signaling.[4,5] The main factors underlying the laser's therapeutic effects are increased reactive oxygen species (ROS), adenosine triphosphate (ATP), and nitric oxide (NO). Increased ROS activates the endogenous anti-oxidant enzyme systems; increased ATP supplies cells with energy for reparation; increased NO promotes angiogenesis, modulates the inflammatory and immune responses, and mediates vasodilation.[4,5] The fundamental step that eventually results in the production of increased ATP is photostimulation of the enzyme cytochrome c in the mitochondrial respiratory chain. Cytochrome c absorbs light in the spectrum of 500 to 1000 nm (therapeutic window) and breaks the bond with NO, which allows bonding with oxygen and production of cytochrome c oxidase at an optimal rate. Cytochrome c oxidase is responsible for the formation of ATP. Additional electrons are accepted by oxygen to produce ROS.

PBMT reduces the pain and inflammation of osteoarthritis and joint disease through several mechanisms of action. PBMT has been shown to reduce cyclooxygenase 2 and bradykinin production (bradykinins induce pain by stimulating afferent nociceptors).[6] Cytokines and growth factors that have anti-inflammatory, anti-oxidative, and anti-apoptotic properties are increased. PBMT reduces the production of inflammatory markers such as interleukin 1 beta, tumor necrosis factor alpha, and prostaglandin E2.[6] PBMT decreases neutrophils in joint fluid, relieves pain, and increases joint mobility and function.[6] PBMT decreases inflammation in tendons and ligaments while increasing tensile strength, collagen fibril size, and fibroblast production.[7] Research has shown that after cruciate transection and subsequent tibial plateau-leveling osteotomies, PBMT reduces cartilage degeneration and synovial inflammation and improves peak vertical force.[7] It has also been shown to accelerate bone healing and promote recovery of atrophied muscles.[7] All these PBMT effects can be amplified when combined with multimodal therapy for the treatment of joint disease.

**TABLE 2 Laser Classification***

| CLASS | DESCRIPTION |
|---|---|
| 1 | ▪ Not hazardous to the eyes and requires no eye protection.<br>▪ Examples: laser printers and CD players. |
| 1M | ▪ Not hazardous to the eyes unless using optical instruments such as binoculars or microscopes. |
| 2/2M | ▪ Limited to 1 mW of power.<br>▪ No protective eyewear is needed, but extended viewing is not recommended.<br>▪ This class includes point-of-sale scanners. |
| 3R | ▪ Have output of up to 5 mW.<br>▪ Are not a fire hazard.<br>▪ Only an optical hazard if focused or viewed for an extended period of time. This class includes laser pointers. |
| 3B | ▪ Have output of up to 500 mW and wavelengths from 300 nm up to the far infrared.<br>▪ Requires protective eyewear.<br>▪ This class includes therapy lasers from 5 to 500 mW. |
| 4 | ▪ Have output greater than 500 mW.<br>▪ Can burn skin or cause permanent eye damage.<br>▪ Protective eyewear must be worn when operating these devices. |

**Adapted from a table published in "Fundamental information" in* Veterinary Medicine: Photobiomodulation.[8]

**BOX 1 Benefits of Laser Therapy for Joint Disease**

- Pain reduction
- Reduced markers of inflammation in the joint
- Reduced swelling and edema
- Increased joint mobility and function
- Stimulation of collagen synthesis
- Decreased dosage or frequency of pharmaceutical use for patients with chronic disease

*Adapted from "Musculoskeletal Disorders and Osteoarthritis" in* Laser Therapy in Veterinary Medicine: Photobiomodulation.[6]

## LASER FUNDAMENTALS AND CLASSIFICATIONS

Fundamental PBMT terms and definitions are summarized in **TABLE 1**.[7] All lasers are classified according to potential to cause optical damage by wavelength, power, and exposure duration. Classes 3B and 4 can be used safely; however, classes 1, 1M, 2/2M, and 3R are not appropriate for any use in veterinary rehabilitation. **TABLE 2** describes laser classifications.[8]

### Tissue Penetration

One of the most critical elements of laser therapy is depth of penetration. Laser light is monochromatic, collimated, and coherent, enabling it to penetrate through tissues to a cellular level. When light interacts with biological tissue, it is either absorbed, scattered, or reflected.

#### Wavelength

A therapy laser will emit light in the 620- to 1200-nm range, often called the therapeutic window. Wavelengths that minimize scattering and reflection as well as absorption by unwanted chromophores will provide optimal penetration into the tissue and ensure a better therapeutic result.[1] Melanin, hemoglobin, and oxyhemoglobin chromophores absorb shorter wavelengths (600 to 800 nm), making these wavelengths better for superficial areas. Wavelengths above 1000 nm are primarily absorbed by water, making tissue penetration difficult. Surgical lasers, such as the $CO_2$ laser, produce wavelengths around 10,600 nm, which are strongly absorbed by water and therefore can be used for surgical applications.[1,6] Wavelengths of 800 to 1000 nm can achieve appropriate depth of penetration to treat most musculoskeletal conditions.

#### Power and Duration

Penetration depends on wavelength and tissue type, not laser power (watts [W]) or laser intensity (irradiance) at the tissue surface ($W/cm^2$). Using a higher-powered laser delivers more photons to the penetration depth and also determines the time needed to deliver the energy. Lower-powered lasers must be used for a longer time to achieve the same dose. Very low-powered lasers will have no measurable results even when used for long periods of exposure.[1,6]

### Dosage

#### Manual

Another consideration with regard to PBMT is dosage applied to the tissue. Dosage is expressed as the amount of energy (joules [J]) delivered to a certain surface area ($cm^2$). When calculating the correct dose, the therapist must consider the size of the patient, body type, coat length and color, skin color, and depth of the condition to be treated. When joint conditions are being treated, the dose can be influenced by the size of the patient, whether the fur is clipped, and the joint involved.[1,6,7] In general, the larger the patient, the larger the dose required for a therapeutic effect. For most joints, 8 to 12 J/$cm^2$ will work well; however, for some joints (e.g., the elbow), a higher dose may be required.[9] **TABLE 3** lists commonly used doses for joints[1] and **BOX 1** summarizes the benefits of PBMT for joint disease.

#### Preset

Many of the newer laser units have preset protocols for treating various conditions. The operator inputs parameters such as size, coat length and color, and area and condition treated, and the machine uses this input to calculate the fluence required. Settings can be manually changed if the therapist wishes to adapt or change the dose. Protocols vary with the manufacturer, and it is in the best interest of the patient for the practitioner to understand laser dosimetry. However, the presets on newer machines have increased safety features and enable veterinarians to confidently delegate delivery of the therapy to well-trained persons.[6]

## TREATMENT TECHNIQUES

Before beginning treatment, ensure that the patient is wearing protective eyewear and is comfortable and appropriately positioned, providing good access to the area being treated. If that area is a joint, ensure access to all sides of the joint. Passive range of motion therapy before and after PBMT is a good idea to ensure improved function.

Treatment techniques will vary according to the condition treated, the joint treated, and the type of laser used. In general, clipping the area will allow the best penetration of light to the underlying tissues; however, if clipping is not possible then the dosage needs to be adjusted. Be cautious not to overheat the coat or skin if using lasers with higher wattage or wavelengths less than 900 nm.

When treating joints, treat a broad area. For example, treat the specific joint and surrounding muscles and tendons as well as satellite areas of pain. Treating a comprehensive area will ensure a more consistent outcome.[1]

Treatment technique will vary with the laser used. Lower-powered lasers (less than 1 W) can use a point-to-point method in which a dose is delivered for up to 30 seconds in 1 location before the probe is moved. This method can be more time-consuming, depending on which joint is being treated and whether multiple joints are involved. Higher-powered lasers use a scanning method that delivers the dose over a large area, ensuring that the handpiece is moving during treatment. The therapy can be delivered with a contact or off-contact method, depending on the unit. The contact method allows for tissue compression and can cause deeper penetration. The off-contact method is frequently used over bony prominences or excessively painful areas.[1]


**FIGURE 1.** Patient undergoing laser therapy. Note the protective eyewear, soft surfaces, and minimal restraint.

For acute or chronic painful joint conditions, it is useful to begin with an induction phase of treatment, followed by more frequent treatment sessions until a significant effect is noticed. For patients with acute joint injury or a flare-up of chronic arthritis, daily treatment is recommended. After clinical signs have improved significantly, then treatments can be reduced to twice weekly for 2 to 3 weeks and then further reduced to maintenance according to the patient's response. It is not unusual for patients with osteoarthritis to receive treatment every 3 to 6 weeks, depending on response. In general, 4 to 6 treatments are needed to see improvement, although 8 to 10 sessions may be needed for patients with multiple joint involvement or severe disease. Be sure that clients are aware that each patient responds differently to PBMT.[6]

## USE OF PBMT WITH METAL SUTURES AND IMPLANTS

Smooth metal implants and staples will primarily reflect diffuse near-infrared light; thus, heating of the implants is not a concern. However, with small patients (e.g., cats and small dogs) the implant will be covered

**TABLE 3 Common Laser Doses for Small Animal Joints***

| JOINT | DOSE |
|---|---|
| Carpus | 1-4 J/cm$^2$ |
| Elbow | 4-8 J/cm$^2$ but may be up to 20 J/ cm$^2$ for chronic conditions |
| Shoulder | 8-10 J/cm$^2$ |
| Hip | 10-12 J/cm$^2$ or higher for large breed dogs |
| Stifle | 4-8 J/cm$^2$ for small dogs; 10-12 J/cm$^2$ for large breed dogs |
| Tarsus | 1-4 J/cm$^2$ |

**Adapted from a table published in "Therapeutic Laser in Veterinary Medicine" in* Veterinary Clinics of North America: Small Animal Practice.[1]

by superficial tissue only. Because of the light reflection, these areas will need an increased dose; therefore, to ensure patient comfort, adjustments need to be made to decrease the power or time of treatment. Because the light does not penetrate the hardware, apply the laser 360 degrees around the limb. Do not hover the laser over sutures; instead, apply the laser to both sides of the suture line.[6]

## PRECAUTIONS FOR PBMT USE

Keep in mind the following safety precautions when using PBMT:[1]

1. Use protective eyewear (for patient and therapist), specific for the laser being used.
2. Do not treat over a pregnant uterus or open fontantelles.
3. Do not treat over malignancies.
4. Remove all metal from the patient (e.g., jewelry, leashes, collars).
5. Use caution with dark skin (melanin increases absorption by chromophores). Use your hand to monitor skin temperature while PBMT is being applied.

## SUMMARY

PBMT is a valuable modality that can be used to treat a variety of joint conditions in dogs and cats. For PBMT to be effective, the dose must be appropriate for the particular condition, joint, and patient. Additional veterinary clinical studies are required to document further benefits and determine optimal parameters for all applications. **TVP**

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