Osteoarthritis and other musculoskeletal disorders such as ligament injuries, fractures and more, are common in companion animals. Laser therapy, also known as photobiomodulation (PBM) therapy, is becoming an alternative treatment option of choice for these patients.

PBM Therapy for Musculoskeletal Disorders in Companion Animals

BY LISA MILLER, DVM, CCRT, CVA

A growing number of pet owners and veterinary practitioners are seeking adjunct or alternative approaches for treating chronic painful conditions, including osteoarthritis and other musculoskeletal disorders, in companion animals. Laser therapy, or photobiomodulation (PBM) therapy, is fast becoming a best practice modality for a variety of these conditions. Though PBM may be utilized as a standalone therapy — and in some cases, the results may be better than treatment with NSAIDs alone[1] — it is better appreciated as part of a multimodal approach for comprehensive pain management and rehabilitation in veterinary patients.

The basic photochemical processes initiated by PBM on a cellular level have been described in previous articles; however, quite a few overarching short and long-term analgesic and anti-inflammatory physiological effects, as well as effects on modulating cell behaviors and enhancing tissue repair, make this modality particularly useful for treating musculoskeletal conditions.[2]

DOSIMETRY FOR MUSCULOSKELETAL CONDITIONS AND GENERAL TREATMENT RECOMMENDATIONS

Dosing PBM for musculoskeletal conditions is usually described in terms of the recommended fluence, or energy density (joules/cm^2), administered to a specific anatomical area measured in square centimeters and applied at the skin's surface. It is possible to achieve the same energy density in a number of different ways by adjusting either treatment time or power in watts (1 W = 1 J/s), depending on the laser device.

Treating at higher power allows the same amount of energy (in joules) to be delivered in a shorter time frame than at lower power, although this may not be the only benefit when it comes to deeper tissue conditions. A recent review study looking at efficacious in vitro and in vivo PBM research concluded that the parameters of most importance in PBM treatment success

are *both* irradiance (mW/cm^2) and fluence (J/cm^2)[13]. A minimum threshold of irradiance at the target tissue must be met in order to appreciate a therapeutic result, while a large percentage of light is lost in transmission from the surface of the skin to deeper tissues. This means the fluence and irradiance at the skin's surface required to produce a therapeutic effect is higher for so-called "deep tissue" conditions, including musculoskeletal disorders, than for "superficial conditions" such as wounds.

One of the conclusions of this review study was that ineffective in vivo results are more likely due to underdosing. As always, in order to optimize treatment, further studies should be encouraged using consistent reported parameters to truly examine the factors necessary for real world clinical efficacy.

In the veterinary literature for orthopedic conditions, positive outcomes have been reported for a general range of fluences between 5-20 J/cm^2 based on the size of the patient and the area and depth of tissues being treated.[1,14-17] The power (W) used to achieve the desired fluence should be lower for smaller patients, for areas with increased sensitivity, and when the target tissues are not as deep. Software protocols in various laser units differ from company to company, and the laser operator should speak with the manufacturer of their device and have a complete understanding of the dose used for each condition and size area intended for treatment within these protocols. While convenient, however, these software protocols should not replace a thorough understanding of dosimetry, and they should always be checked against the practitioner's calculations to ensure an effective treatment dose is being delivered.

PBM being applied on the carpus.

Most importantly, based on the Principle of Photochemical Activation, photons must reach and be absorbed at the site of "injury" for PBM to be effective.[18] Knowing where to treat is essential. All veterinary patients should undergo a thorough orthopedic and pain examination, not only to treat the correct sources of pain, but also to identify any compensatory changes in soft tissue. A pain examination should be repeated regularly for all patients to evaluate progress, ensure all painful areas are treated, and follow up with any additional diagnostics or other therapies if needed.

If possible, when treating musculoskeletal conditions, the laser treatment head/hand piece should be held in contact with the skin over the affected area, and moved so the entire area is treated evenly. Using contact and applying pressure to the skin creates tissue blanching (dispersal of blood from the dermis and fat tissues)[19] and minimizes light losses (which can be significant) due to reflection off the skin.[20,13] Some patients with pain may be hypersensitive to physical touch, especially over bony prominences (e.g. elbow and stifle). In these patients, or in those with open wounds or surgical incisions, a non-contact treatment method may be necessary in certain areas. If the patient has a soft bandage or other covering in a post-surgical situation, PBM should be applied during bandage changes since it cannot be performed through bandage, splint, or casting materials.

A Short Review of PBM

As a brief general review, PBM uses wavelengths in the red and infrared range to activate cytochrome c oxidase and increase mitochondrial electron transport, inducing a cascade of events leading to an increase in adenosine triphosphate (ATP).

Photo courtesy of Bridge Animal Referral Center

PBM therapy for abdominal organs.

This produces beneficial reactive oxygen species (ROS) and nitric oxide, affecting healing and stimulating collagen production via the upregulation of specific substrates and cytokines (including EGF and TGFβ), and the downregulation of others (e.g. interleukin IL-6, IL-8, and IL-1)[3-8] in treated tissues.

PBM modulates the inflammatory process, and while this is a large part of why it is beneficial for pain relief, it also reduces the sensitization of injured or inflamed peripheral neurons, the dorsal root ganglion (DRG) and spinal cord via modulation of ion channels. In some situations, it also inhibits Aδ and C fiber transmission.[9-12]

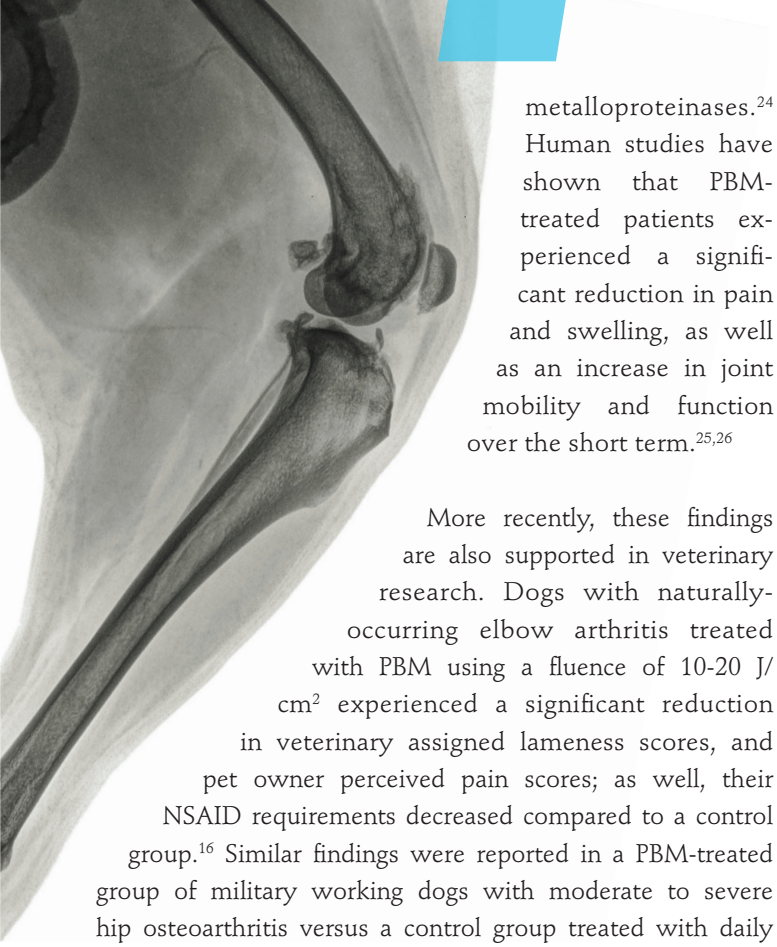
When initiating a course of PBM therapy, the patient may be very stiff and painful during the first few visits. It is best to first address the animal's discomfort while allowing them to lie or sit on a padded surface, and treat the affected limb(s) in a passive position that allows access to the structures involved. During subsequent treatment sessions, while administering laser treatment over a joint area, the limb may be gently placed through its passive range of motion, if possible and desired.

For any acute or chronic pain condition, an "induction phase" of initial, more frequent treatment sessions is recommended (usually daily to every other day until significant improvement is noted). Following this, the patient can enter a "transition phase" during which treatments are decreased to twice weekly, then once weekly, and so on as the patient improves until the condition resolves (e.g. a soft tissue injury). Alternatively, a "maintenance phase" of treatments is established if the condition is expected to be ongoing (e.g. osteoarthritis). For musculoskeletal conditions, chronic treatment is typically one session every two to six weeks, based on the patient's response with a goal of minimizing clinical signs.

1 OSTEOARTHRITIS

Affecting as much as 20% of the U.S. pet population over the age of one year,[21] osteoarthritis (OA) is a progressive syndrome involving the interaction of a multitude of factors. Current treatment strategies in veterinary medicine are aimed primarily at controlling pain, improving joint function, and minimizing functional incapacity in patients through various strategies such as proper weight management, nutraceuticals, pharmacologic therapy, rehabilitation therapy, and when necessary, surgical intervention(s).

One of the most common uses of PBM is for the treatment of chronic pain associated with osteoarthritis. Animal and human trials have shown the modulatory effect of PBM therapy on inflammatory markers and other aspects of the inflammatory process in OA. Studies have demonstrated that treating arthritic joints with PBM reduces edema and the influx of leukocytes,[22,23] decreases the concentration of IL-1β and IL-6 in synovial fluid,[23] and reduces the activity of



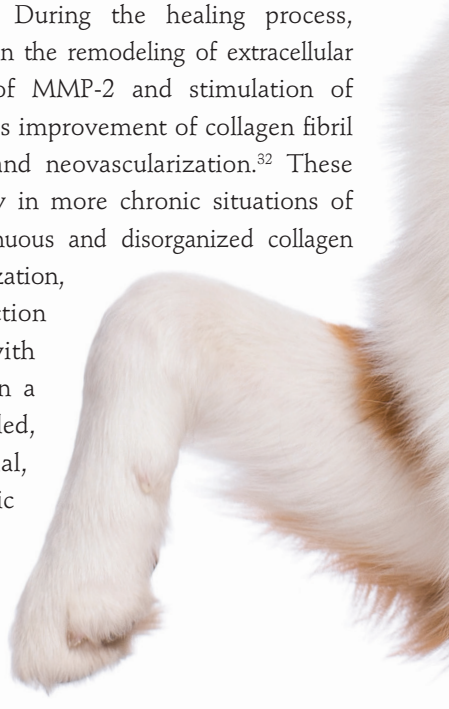
metalloproteinases.[24] Human studies have shown that PBM-treated patients experienced a significant reduction in pain and swelling, as well as an increase in joint mobility and function over the short term.[25,26]

More recently, these findings are also supported in veterinary research. Dogs with naturally-occurring elbow arthritis treated with PBM using a fluence of 10-20 J/cm^2 experienced a significant reduction in veterinary assigned lameness scores, and pet owner perceived pain scores; as well, their NSAID requirements decreased compared to a control group.[16] Similar findings were reported in a PBM-treated group of military working dogs with moderate to severe hip osteoarthritis versus a control group treated with daily meloxicam for three weeks. Not only did the PBM group experience longer periods with better results versus the NSAID control group, but they also had improved range of motion in the joint up to 90+ days with just three weeks of PBM treatment.[1] These results offer a possible alternative of PBM treatment in lieu of systemic NSAIDs, especially early in the diagnosis of osteoarthritis.

Patient preparation, techniques for laser administration, dosing information, and recommended frequency are as described above. While radiographic changes are supportive of an OA diagnosis, they may not be consistent with the level of pain displayed by a patient in a particular area. The PBM treatment area(s) prescribed should be primarily based on orthopedic and pain assessment examinations.

2 TENDON AND LIGAMENT INJURIES

With regard to tendon injuries and tendonitis, PBM literature has focused primarily on the exertion of an anti-inflammatory effect after injury, with reduction of pro-inflammatory mediators.[27,28] During the healing process, PBM results in improvement in the remodeling of extracellular matrix through activation of MMP-2 and stimulation of collagen synthesis,[29] as well as improvement of collagen fibril size,[30] fiber organization,[31] and neovascularization.[32] These same benefits can also apply in more chronic situations of tendinopathy where discontinuous and disorganized collagen fibers, abnormal neovascularization, edema, and impaired function can present in patients with overuse tendon conditions. In a randomized, placebo-controlled, double-blinded clinical trial, human subjects with chronic lateral epicondylitis received eight treatments with either sham or real laser. The laser-treated group demonstrated improvement in handgrip



PBM for Muscle Tissue

Photo courtesy of Milton Animal Hospital

PBM therapy being applied on hip.

PBM provides several benefits for muscle tissue, but the most prevalent effects reported in current literature involve the prevention of muscle damage after exercise, including delayed onset muscle soreness, and the improvement of muscle performance.[41-43] Clinically, there are still many unanswered questions regarding the use of PBM in canine athletes, including the timing of PBM application to muscles (before, during, or after exercise), the ideal dosimetry, and the exact mechanisms of how PBM interacts with muscle tissue to increase sports performance.

When it comes to the ideal timing for treating muscle tissue, the current body of evidence reports two main strategies for the use of PBM to increase muscle performance and exercise recovery in clinical trials.

The first strategy is the use of muscular pre-conditioning. Numerous rodent and human studies have demonstrated that patients treated with PBM in various time frames prior to exercise are able to perform more repetitions in muscle fatigue tests and have improved muscle energy metabolism compared to control groups.[44-48] Studies in humans demonstrated the best improvement anywhere from 40 to 60 minutes to three to six hours prior to exercise.[43,49-51] The second strategy applies PBM immediately after exercise in order to accelerate muscle recovery and help heal any muscle injuries via a variety of mechanisms. [49,50,52-54]

PBM may also be used any time there is muscle swelling or pain from a variety of causes. It has been used to treat experimentally-induced myositis in rats,[55] resulting in a significant reduction in the presence of inflammatory cells and in the amount of edema present in tissue after treatment. Additional studies on experimental myopathy showed significant changes in inflammatory biomarkers and infiltrates, oxidative stress, and improved muscle recovery.[56]

Regarding dosimetry for performance enhancement or muscle recovery and painful conditions, it is logical and in accordance with previous deep tissue veterinary studies to suggest dosimetry similar to that mentioned in the article, along with treating the largest area possible over the main muscles involved in a particular exercise/sport or injury respectively.[49,57]

strength, enhanced function, and a continuous reduction in pain over a 12-month period, despite return to normal activity.[33]

The dosing and frequency of treatments is typical for deep tissue musculoskeletal conditions, with consideration given to the location (depth) of the tendon and other associated soft tissues when selecting power parameters. It should be noted that patients experiencing an acute exacerbation of tendonitis or tendinopathy may be very hypersensitive to pressure, temperature, or both, and that adjustments in treatment power (W) or non-contact versus contact may be necessary.

Some studies have examined cranial cruciate ligament injury and the outcome measures following surgical repair and/or progression of subsequent osteoarthritis in the knee if no surgery was performed. In lab animal models, laser treatments starting immediately after cruciate ligament transection were shown to prevent some features of articular degeneration of the knee, reducing synovium inflammation, cartilage damage, and knee pain.[34,35] In 2017, Renwick et al utilized PBM in dogs for three postoperative treatments following TPLO surgery, and found a greater improvement in the gait section of the adjusted Canine Orthopedic Index questionnaire.[36] Rogatko and colleagues investigated the use of PBM as a single preoperative treatment for the same surgery, and found a significant difference in peak vertical force (PVF) in the PBM-treated group. As well, a higher percentage of patients were healed at eight weeks post-op.[15] Neither of these studies showed significant differences in bone healing; however, this author would refer back to previous comments regarding the increased dosing needed for deep tissue conditions. In the former canine study, doses listed in the appendix section show laser settings that were less than 50% of those recommended for deep tissue conditions (including bone healing), perhaps suggesting that dosimetry, while adequate for some pain relief benefits, was not high enough for other outcomes to be significant.

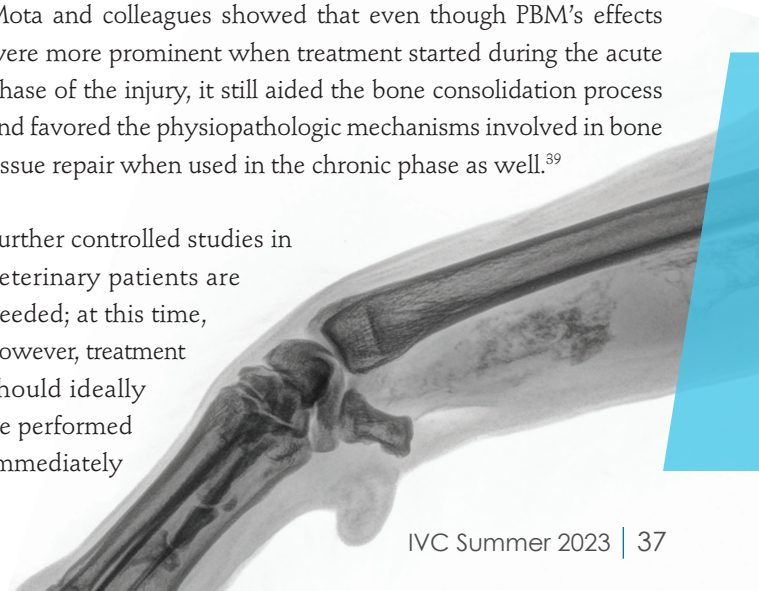
Treatment with PBM therapy should begin immediately after CCL surgery (if not before) to address pain and inflammation and assist in wound healing. The incisional area and affected superficial soft tissues may be treated with a more superficial target energy density of 4-6 J/cm^2, and with a lower power (W) setting than would be used in a deeper tissue dose for the stifle joint itself. Deeper soft tissues of the anatomic region that are painful or bruised, or become edematous after surgery, may be treated with a higher fluence (~10-20 J/cm^2, depending on the size of the patient). The laser operator should also consider treating the contralateral stifle, due both to the predisposition of CCL tear on the opposite limb as well as compensatory weight shifting. The author also recommends examination and possible treatment of the iliopsoas muscle and lower back, since these areas are often also quite painful in these patients. In acute postoperative situations, treatment should ideally be performed daily, if possible, for the first 24 to 72 hours, then twice to three times weekly, as with other chronic conditions, tapering as the patient improves.

When treating partial or complete CCL tears managed conservatively in some other fashion (bracing, etc.) due to any reason (financial restrictions, co-morbidities, etc.), expectations should be set with the pet owner that the goal of PBM treatment is only for pain management along with reducing inflammation and possibly cartilage damage. Typical dosing for deep tissue musculoskeletal conditions should be used. Treatment for the stifle should include a relatively large area, incorporating all the important soft tissue structures in the area, including the insertion of the hamstring muscles and the patellar ligament. Ideally, all the above should be performed as part of an appropriate course of physiotherapy, with continuous reassessment and adjustments along the way.

3 FRACTURES AND BONE HEALING

In addition to the analgesic benefits PBM brings to fracture repair cases, there is evidence in the literature that it can be used in situations where bone healing is desired. In a recent review of 25 relevant articles regarding the use of PBM in bone healing, 11 of 13 in vitro studies showed positive results with regard to the acceleration of cell proliferation and differentiation, and all animal studies showed improved bone healing in laser-treated sites.[37] A later systematic review found that 75 of 76 studies utilizing PBM showed positive effects on fractures in animal models, including acceleration and stimulation of fracture healing as well as callus maturation.[38] Mota and colleagues showed that even though PBM's effects were more prominent when treatment started during the acute phase of the injury, it still aided the bone consolidation process and favored the physiopathologic mechanisms involved in bone tissue repair when used in the chronic phase as well.[39]

Further controlled studies in veterinary patients are needed; at this time, however, treatment should ideally be performed immediately



after stabilization, and then done twice weekly for a total of six to eight treatments.[40] A target energy density suitable for deep tissues (10-20 J/cm^2) is recommended, scaling up with depth of the soft tissues overlying the area. The entire area to be treated should include not only the soft tissues overlying the fracture itself, but several square centimeters proximal and distal.

In summary, a large body of research in both veterinary and human medicine elucidates the potential beneficial effects of PBM on conditions of the musculoskeletal system. Further research should be encouraged to uncover additional molecular mechanisms, timing of treatment, and optimal dosing parameters for various conditions. We should not forget this modality when managing veterinary patients for these common conditions.

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From the AVH

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VETERINARY GASTROENTEROLOGY AND HOMEOPATHY

Good food and nutrition are paramount to our veterinary patients' health. Chronic disease can hinder good nutrition, and a poor diet can be an obstacle to homeopathy. A mistuned vital force cannot use even the most excellent food very well until the correct remedy is given.

The imbalance caused by chronic disease impedes normal digestion. As a truly homeopathic remedy restores balance, digestion improves, resulting in enhanced tissue health and organ function.

Here are some key acute remedies to consider for gastrointestinal symptoms:

- *Arsenicum album* — keynote is restlessness; vomiting and diarrhea (foul odor); often bloody stool; craves frequent small sips of cold water; food poisoning or garbage ingestion.
- *Ipecac* — nausea and vomiting at the mere smell of food; no thirst; bloody stool; gets diarrhea easily.
- *Nux vomica* — a top remedy for many gastrointestinal issues; treats bad effects of drugs and chemicals; overeating; seizure prone; frequent urge to stool; irritable/oversensitive/grumpy when ill.

The following are two important remedies for chronic disease, often helpful with gastrointestinal symptoms:

- *Calcarea carbonica* — a very important nutritional remedy; keynote is poor growth/development; stunted appearance; distorted breeds; delayed dentition/retained deciduous teeth; orthopedic problems/arthritis.
- *Sulphur* — good appetite but thin; slow, lazy; unkempt appearance; looks old; anus and mouth red/inflamed; bloody discharges with odors; swollen belly; thin legs; liver problems.

Since it is hard to distinguish poor nutrition from chronic disease, try the following approach:

1. Improve diet as much as possible.
2. Treat with the best homeopathic remedy for the total symptom picture (no suppressive treatments).
3. Eliminate obvious drugs and chemicals from the picture if possible

You can find a veterinary homeopath at *theAVH.org*.

Submitted by Todd Cooney, DVM, CVH