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PRACTICAL ULTRASOUND OF THE EQUINE STIFLE: PART ONE

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GETTING STARTED ON THE RIGHT FOOT

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TOOLS OF REHABILITATION: PART ONE

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LIGHT AMPLIFICATION BY STIMULATED EMISSION OF RADIATION (LASER) THERAPY

Laser devices emit light through a process of optical amplification based on the stimulated emission of electromagnetic radiation.

There are more than 5000 research papers looking into low-level laser therapy (LLLT) and around 50 looking into high-power lasers. Within this body of research, laser therapy has been reported to expedite the inflammatory process, decrease pain and promote tissue healing (promote fibroblast proliferation, promote synthesis of type 1 and 3 procollagen mRNA), expedite bone healing and help in revascularization of wounds amongst other things.

MECHANISM OF ACTION

It is thought that the mechanism of action is associated with the ability of cells to absorb light photons (energy) and transform that energy into ATP, reactive oxygen species and nitric oxide. The increased ATP is suggested to promote homeostatic function of the cells, the reactive oxygen species are thought to increase immune function at certain levels, whilst nitric oxide has a dual function of increasing circulation and relieving pain.

Different classes of laser:

1. Low level: power < 500 mw. Wavelengths: 540nm-1060nm
2. High power, class IV: power > 500 mw. Wavelengths: 790 nm-980nm. Much of the energy from a high-power laser is converted to heat and absorbed by water in the tissues.
3. Multi Radiance laser—classed as low level but which use combinations of multiple wavelengths to produce their effects. The synchronous use of high-power super-pulsed laser wavelength (905nm), ultra-bright infrared (875nm), red (640nm) and blue (465nm) LEDs are suggested to optimize the biological effects of the entire phototherapeutic window to accelerate healing and reduce pain.
   - Multi Radiance lasers use super-pulsed diodes, which are more advanced and more expensive than continuous lasers. It is important to note that a super-pulsed diode is not the same as just 'pulsing' a continuous wave laser. Super-pulsed diodes enable a Multi Radiance laser to safely super pulse up to 50,000 mw of power—more than most class IV lasers.

Light is measured in wavelengths and is expressed in units of nanometers (nm). Different wavelengths stimulate different chromophores that have various effects on tissues. In general, the longer the wavelength, the deeper the penetration into tissues. The wavelength of light used for LLLT falls into a 'therapeutic window' at red and near infrared wavelengths (600-1070nm). Effective tissue penetration, in humans, is optimized in this range. Wavelengths in the range 600-700 nm are used to treat superficial tissues, and longer wavelengths in the range 780-950 nm are used for deeper tissues.[27] Wavelengths below 600 nm are strongly absorbed by the tissue chromophores, hemoglobin, and melanin, while those above 1000nm are readily absorbed by water. Protocols for treatment of wounds, tendinitis, desmitis, osteoarthritis (OA), and muscular soreness are available for horses—but are mainly extrapolated from human or *in vitro* studies.

SCIENCE

Whilst both *in vivo* and *in vitro* studies have reported the biologic effects of laser, including increased fibroblast and collagen production, improvement of collagen fiber alignment and increased angiogenesis, as well as decreased levels of pro inflammatory mediators such as PGE-2, in general, veterinary reports on the clinical effects are ambiguous.[28,29,30] Studies in humans looking at low level laser have, however, been quite optimistic.

HUMAN STUDIES

LLLT in human osteoarthritis patients has been suggested to have a positive analgesic effect.[31] Additionally, both red and infra-red LLLT have been shown to be effective at delaying the development of skeletal muscle fatigue and enhancing skeletal muscle performance.[32]

Furthermore, there is growing research on the effects of laser for wound healing and in non-equine studies, the histologic response to low-level laser therapy has indicated a reduction in inflammation, edema, and an increase in collagen synthesis.[33,34,35] Although the research is notoriously conflicting and confusing at times, a 2004 metanalysis evaluating the efficacy of laser to treat wounds in humans concluded that laser therapy is an effective tool for promoting wound healing.[36]

EQUINE-SPECIFIC RESEARCH

A recent study in 2018 followed 150 sport horses diagnosed with tendinopathy/desmopathy that were treated with a high power (class IV) laser. A laser protocol was initiated two days following diagnosis of injury and all horses were treated for 20 minutes a day for two consecutive weeks. All limbs were clipped prior to application of laser therapy. Within two to six weeks after initiation of treatment, a significant improvement in lameness and ultrasonographic scores was reported. Authors suggested that laser therapy as a sole therapy might be clinically favorable. Although no negative effects from the use of high-power laser were documented, limitations of this study included the fact that other treatment modalities were being used concurrently in many cases; there were no controls; and there was a disparity in rehabilitation protocols.[37]

Other areas of study for laser use in horses include the back, with one study using low-level laser documenting that 10 out of 14 horses with back pain showed clinical improvement after lasering specific acupuncture points.[38] A 2020 study looking at the effects of low-level laser and chiropractic treatment on back pain concluded that laser therapy alone produced significant reductions in back pain and trunk stiffness in a population of quarter horses involved in active competition, whilst chiropractic therapy did not. The combination of chiropractic and laser provided some additive effects in treating back pain and trunk stiffness, supporting the concept that a multimodal approach is beneficial for rehabilitation.[39]

Importantly, some recent equine studies have addressed the question of 'penetration depth' related to laser competence. Historically, *in vitro* studies have documented a level of laser efficacy that cannot be replicated *in vivo*. Lack of *in vivo* penetration, especially of low-level lasers, has been suggested to be the reason for this discrepancy. A 2016 equine cadaver study using a class IV laser documented that penetration of laser energy through equine skin samples was affected by the presence of hair and by the pigment of the skin. The darker the skin pigmentation the less the laser energy was able to penetrate the skin, with as little as 1.9% of emitted laser being reported to penetrate shaved black pigmented equine skin in that study. Data obtained supported clipping or shaving hair prior to laser treatment and advised that laser energy choices be based on skin pigmentation.

Figure 4. The main advantages of Multi Radiance lasers (eg ACTIVet PRO™) are the greater penetration depths reported in unclipped skin, which includes most of the patients we see, and its excellent safety profile, which allows it to be used at FEI events, unlike a class IV laser.
Image courtesy of Dr. Sarah Plevin.

Equally, that study reported that successful treatment of the deep digital flexor tendon and suspensory ligament should not be directed through the skin and the superficial digital flexor tendon but from medial or lateral aspects.[40] A 2020 study looking at the penetration profiles of a class IV laser (LightForce™) versus a Multi Radiance laser unit (ACTIVet PRO™) also concluded that differences in penetration were attributed to skin color. This study documented the ability of the Multi Radiance laser to provide greater penetration compared to the class IV laser in unclipped light and dark-skinned horses.

Often clipping is not acceptable especially in horses showing/competing and/or if the laser is being used for general maintenance throughout the season. This study, therefore, provides practical evidence that a Multi Radiance laser unit may be the better and more practical clinical therapeutic choice for unclipped horses.[41]

HOW WE USE IT

As Multi Radiance laser technology (Figure 4) has been validated *in vivo*, *in vitro*, in controlled laboratory studies, and in clinical trials, it is the laser technology we most commonly utilize in our practice.[42,43,44] We commonly use it on acupuncture points for back conditions, for tendon and ligament injuries, as well as for wound management.

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