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A Guide to Laser Therapy

Learn the foundational science behind the therapy

INTRODUCTION

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UNDERSTANDING LASER THERAPY TERMINOLOGY

"Cold Laser", "Low-Level Laser Therapy (LLLT)" and "Low-intensity Laser Therapy (LILT)" are all terms previously used in the laser therapy field.

Photobiomodulation Therapy (PBM) was added to the meSH database in November 2015 and is the preferred name for researchers and key opinion leaders in the field because it clearly characterises the modality.

While both high power and low power lasers can deliver photobiomodulation therapy, it is important to note that high power lasers are differentiating themselves from their low power counterparts.

More recently, based on a consensus in the field, the term photobiomodulation therapy (PBMT) was added to the National Library of Medicine MeSH database as an entry term to the existing record of laser therapy.[1]

In general, all these terms refer to "treatment using irradiation with certain wavelengths of light which create biochemical changes in tissues once absorbed." With the recent advancement of laser technology producing higher power devices (>0.5 W), this therapy can create warmth on the surface of the skin during treatment but the main mechanism of action is biochemical effects from light rather than heat.[2]

Unfortunately, these terms do not comprehensively describe the mechanisms related to therapy lasers, nor do they adequately distinguish them from other light-based therapies. This lack of clarity has led to significant confusion about the laser modality and a need for better nomenclature.[1] In September 2014, the North American Association for Light Therapy (NAALT) and the World Association for Laser Therapy (WALT) convened and agreed upon the term "Photobiomodulation Therapy" as the preferred nomenclature. Photobiomodulation Therapy (PBM) was added to the MeSH database in November 2015 and is the preferred name for researchers and key opinion leaders in the field because it more clearly characterises the modality.[1]

Even with this declaration from the laser therapy organisations, a variety of terms continue to be used and confusion remains. The key point is that laser therapy, no matter the terminology used, affects the body through a process called photobiomodulation (PBM). "PBM is the mechanism by which nonionizing optical radiation in the visible and near-infrared spectral range is absorbed by endogenous chromophores to elicit photophysical and photochemical events at various biological scales without eliciting thermal damage."[3] It is a mechanism that leads to "physiological changes and therapeutic benefits."[3]

While both high and low power lasers can deliver photobiomodulation therapy, it is important to note that high power lasers are differentiating themselves from their low power counterparts. ***Higher power lasers can deliver more light energy to deeper target tissues, and recent studies demonstrate that these devices can give patients better results than those treated with a low power laser for certain conditions.[3,4,5] Make sure you are optimising your patient outcomes.***

WHAT IS PHOTOBIOMODULATION THERAPY?

Photobiomodulation therapy is defined as a form of light therapy that utilises non-ionizing light sources, including lasers, light emitting diodes, and/or broadband light, in the visible (400 – 700 nm) and near-infrared (700 – 1100 nm) electromagnetic spectrum. This process involves endogenous chromophores eliciting photophysical (i.e., linear and nonlinear) and photochemical events at various biological scales, resulting in beneficial therapeutic outcomes including, but not limited to:

- the alleviation of pain or inflammation,
- immunomodulation,
- promotion of wound healing and tissue regeneration.

The term photobiomodulation (PBM) therapy is now being used by researchers and practitioners instead of terms such as low level laser therapy (LLLT), cold laser, or laser therapy.[6]

The fundamental principles that underpin photobiomodulation (PBM) therapy, as currently understood in the scientific literature, are relatively straightforward. There is consensus that the application of a therapeutic dose of light to impaired or dysfunctional tissue leads to a cellular response mediated by mitochondrial mechanisms that reduce pain and inflammation and speed healing.[7]

The primary target (chromophore) for the process is the cytochrome c complex which is found in the inner membrane of the cell mitochondria. Cytochrome c is a vital component of the electron transport chain that drives cellular metabolism. As light is absorbed, cytochrome c is stimulated, leading to increased production of adenosine triphosphate (ATP), the molecule that facilitates energy transfer within the cell. In addition to ATP, laser stimulation also produces free nitric oxide and beneficial reactive oxygen species. Nitric oxide is a powerful vasodilator and an important cellular signaling molecule involved in many physiological processes. Reactive oxygen species have been shown to affect many important physiological signaling pathways including the inflammatory response. In concert, the production of these signaling molecules has been shown to induce growth factor production, to increase cell proliferation and motility, and to promote extracellular matrix deposition and pro-survival pathways. Outside the cell, nitric oxide signaling drives vasodilation which improves microcirculation in the damaged tissue, delivering oxygen, vital sugars, proteins, and salts while removing wastes.[8]

See Photobiomodulation in Action

Watch this to understand the science behind photobiomodulation.

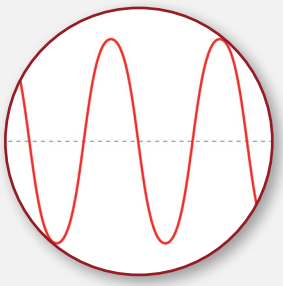
***Watch now**: https://www.youtube.com/watch?v=dB9MIW9fduk&t=4s*

CLICK TO VIEW VIDEO

REACHING TARGET TISSUE

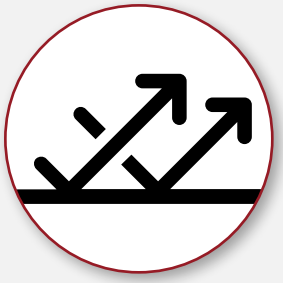
For PBM to occur, light needs to reach the mitochondria of the damaged target tissue. Laser therapy is applied to the surface of the skin. The best clinical results are achieved when a sufficient amount of light (number of photons) reaches the target tissue. There are a number of factors that can help maximise the light that reaches the target tissue.

These include:

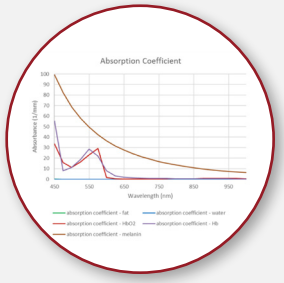


Proper wavelength selection

Sufficient laser power



Reducing reflection off the skin's surface



Minimising absorption by molecules not involved in photobiomodulation (incidental absorbers)

FREE WEBINAR: INTEGRATING TECHNOLOGY INTO PRACTICE: AN INTRODUCTION TO PHOTOBIOMODULATION.

Join Enovis and Physiotherapist James Tomkies to explore the key science behind PBMT, and how it can benefit both your clinic and patients.

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PULSING AND FREQUENCIES

THERAPY LASERS CAN PULSE IN DIFFERENT WAYS

Generally speaking, therapy lasers that pulse either operate in a superpulsed mode or gated mode. In superpulsed mode, a large amount of energy is allowed to build up over a period of time, and then released quickly in a single, large burst of energy. Superpulsed lasers produce very brief pulses (on the order of 200 nanoseconds) of high frequency. The pulses have high peak powers (up to 3000W) with a much lower average power (such as 60 mW).

PHOTOBIOMODULATION THERAPY CAN BE DELIVERED IN EITHER CONTINUOUS WAVE (CW) OR PULSED MODES

As photobiomodulation therapy has become more popular, manufacturers have made elaborate claims about specific pulsing protocols and application-specific wavelengths. These claims can be misleading and can create confusion. In reality these product-specific bells and whistles are more marketing hype than science. A review by Hashmi et al. that looked at CW versus pulsed light concluded that more evidence is needed.[9] In general, the use of pulsing decreases light delivered to the surface and hence to the target.

FREE WEBINAR: SUPER CONFUSED ABOUT SUPER PULSING?

If you're super confused about the role super pulsing plays in laser therapy, you're not alone! In this webinar, Mark Callanen, PT, DPT, OCS will clear up the misconceptions about this abundantly used marketing term. He will address the impact that pulsing and super pulsing have on the key laser therapy treatment principles responsible for clinical successes - and failures.

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WHAT WAVELENGTHS OF LIGHT ARE THE BEST FOR PHOTOBIOMODULATION (PBM)?

The unit to measure wavelength is nanometer (nm)

Current understanding of photobiomodulation is that light in the wavelength range of 800nm to 1000nm is capable of penetrating the skin and tissue surface reaching the muscle below.

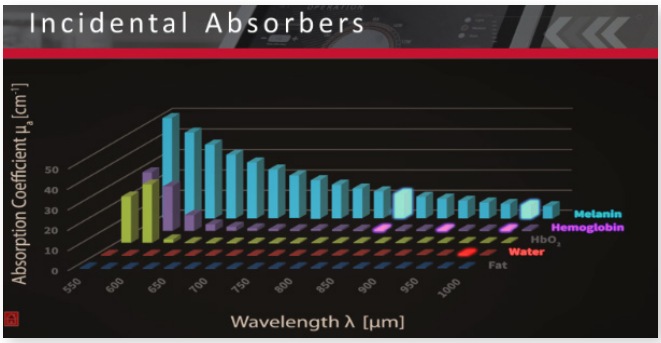
Lightforce Therapy Lasers utilise both 810 and 980nm wavelengths. Our Influence Technology takes into account the patient's unique absorption characteristics and specific clinical condition to help provide the most effective treatment.

Much research has been done to investigate how melanin, blood, fat, and water absorb light, and this has led researchers to define a window or range of wavelengths through which light can penetrate biological tissue. This window is referred to as the optical or therapeutic window.[8]

The main components in the tissue that absorb light are: melanin, oxyhemoglobin, deoxyhemoglobin, fat, and water. Melanin absorbs light strongly in the lower wavelengths, so dark skin will absorb more light, especially the wavelengths from 500 nm to 800 nm. Wavelengths longer than 1200 nm are readily absorbed by water.[8] Lasers with these longer wavelengths are typically used in ablative procedures such as surgery or skin resurfacing. Current understanding of photobiomodulation is that light in the wavelength range of 800 nm to 1000 nm is capable of penetrating the skin and surface tissue and reaching the muscle below.

Figure 1 below shows the dominance of melanin absorption compared to hemoglobin, oxyhemoglobin, water and fat. Generally, red light (600 nm to 700 nm) can be used to treat the conditions near the surface of the skin, but light in the 800 nm to 1000 nm is needed to reach deeper tissue structures.

Figure 1



Linear plot of Absorption Coefficient vs. Wavelength. Data for the absorption coefficients were obtained from Oregon Medical Laser Center, http://omlc.org.

Lightforce Therapy Lasers utilise both 810 and 980 nm wavelengths due to their ability to be preferentially absorbed by musculoskeletal and neural tissues. Our Influence® Technology takes into account the patient's unique absorption characteristics and specific clinical condition to help provide the most effective treatment. Patient specifications such as condition, body type, and skin type are taken into account. The in-depth protocol settings provide recommended parameters on treatment heads and power levels to aid in clinician confidence and reduced learning time. **Not all therapy lasers approach dosing the same way, make sure you ask about how light absorption is being optimised before you invest in a therapy laser.**

WHAT IS LASER POWER AND HOW DOES IT AFFECT PHOTOBIOMODULATION (PBM)?

Power (W) is a measure of the number of photons (light energy) emitted from a laser each second.

Higher powers are needed as the greater the number of photons delivered to the surface, the greater the number of photons at any tissue depth.

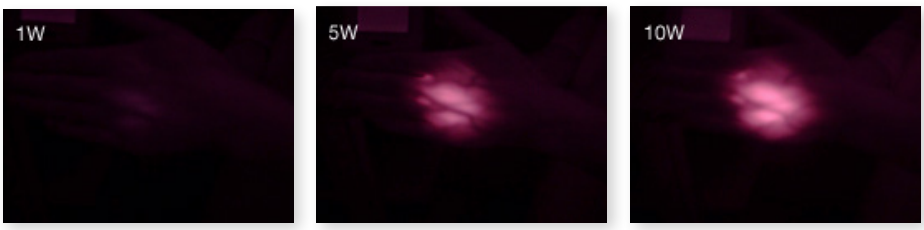
With higher powered lasers, it is possible not only to apply the benefits of PBM superficially, but also to treat a greatly expanded range of conditions.

THE LASER LIGHT ENERGY IS MEASURED BY THE LASER POWER

Power seems simple but simply stating the output power does not relate the whole story when discussing therapy laser treatment. Not only is power important, but also the size of the area that is being treated. Power units for a laser are defined as watts (abbreviated as W). Power is a measure of the number of photons (light energy) emitted from the laser each second (the rate of energy delivery). Early therapeutic lasers had very low powers (less than 0.5 W) and very small beam areas (or spot sizes); consequently, early studies were often disappointing because the low powers were not able to provide sufficient number of photons to reach deeper affected tissue *in vivo* as doses that were optimised *in vitro* did not account for light's losses as it penetrates through skin, fat, muscle, etc.

WHY ARE HIGHER POWERS NEEDED?

Simply stated, the greater the number of photons delivered to the surface, the greater the number of photons at any tissue depth. There is a threshold, a minimum number of photons that are needed to "turn on" the therapeutic effects of laser light. Hundreds of scientific studies have been done *in vitro* and have characterised the dosages needed to achieve a cellular response with light. These studies provide a baseline for the amount of laser energy needed to achieve results at the cellular level. PBM therapy is non-invasive; the light is applied to the surface of the skin. Some of that light is reflected by the skin or absorbed by other chromophores that are not associated with the injured cells and therefore do not contribute to PBM. Sufficient dose needs to be applied to the skin so that despite these losses sufficient dose reaches the target tissues, where PBM then may occur.



The figure illustrates, with infrared images, the amount of light seen on the back of the hand when laser light is applied to the palm at 1 watt, 5 watts, and 10 watts of power.

The greater the power, the greater the penetration to deeper tissue for a given amount of time. With higher powered lasers, it is possible to not only apply the benefits of PBM superficially, but it is also possible to treat a greatly expanded range of conditions by delivering a clinically effective quantity of photons to cells deep within the tissue. Lightforce Therapy lasers not only have the ability to delivery higher power for various conditions, but they also incorporate delivery systems that can efficiently treat tissue in a way that is comfortable to the patient.

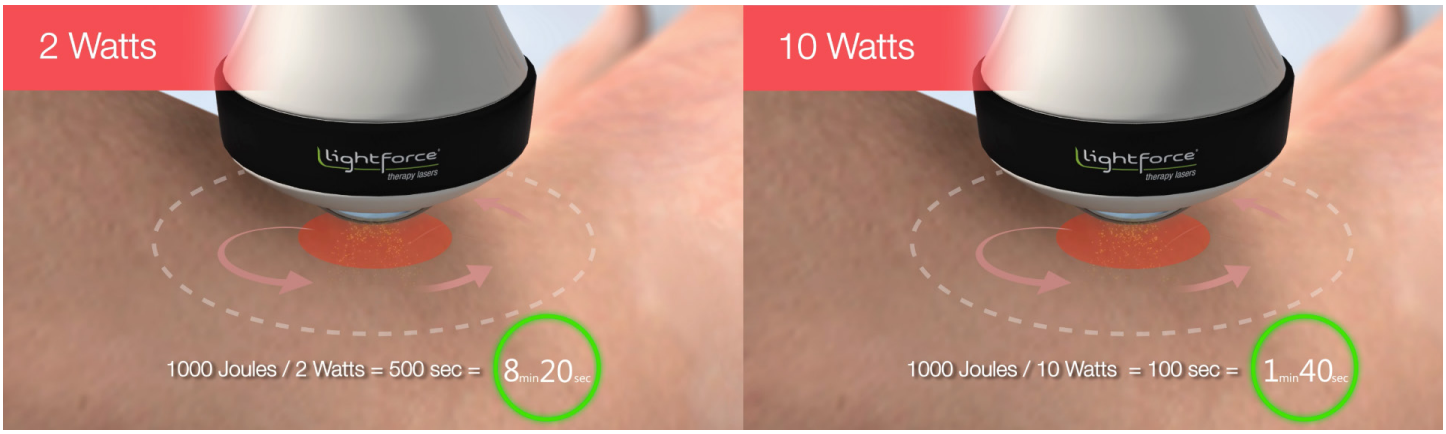
THE ROLE OF POWER IN DOSING

POWER IMPACTS THE FUNCTIONAL DEPTH OF PENETRATION OF THE LASER LIGHT

The combination of treatment time and power determines the therapeutic dose of energy that is received by tissues at depth. If a therapy laser has low power, the total number of Joules it can deliver to relevant depths for treating most musculoskeletal conditions in a realistic treatment time is very low.

When treating with a laser, it can be difficult to maintain therapeutic dosing levels when treating over large surface areas. This is because as the treatment area grows, so does the denominator of the energy density equation (J/cm2) which can dilute the dose of energy being applied if higher joule levels are not applied proportionately. Having more laser power to utilize makes this adjustment easier for the clinician. Note: (J = W x s).

The graphic below helps clarify how adding power impacts treatment time for a given energy density and a given area.



In summary, adding power to the energy equation can significantly reduce the time needed to apply a therapeutic PBM dose of light. Understand the difference between class IV laser therapy and other therapy devices before you invest.

WHAT IS YOUR TIME WORTH?

YOUR TIME IS VALUABLE

Providing your patients with the best care in the most efficient amount of time is a priority. Class IV therapy lasers are a great resource to maximise your staff's efficiency in treating your patients.

With an average treatment time of 4-7 minutes, clinicians can use laser therapy as part of an overall plan of care and maximise the time available to treat.

Provide your patients with a quick, medication-free solution to their pain while maximising staff efficiency in the clinic with a Lightforce Therapy laser.

FREE WEBINAR: INTEGRATING TECHNOLOGY INTO PRACTICE: A CLINICIANS PERSPECTIVE.

Adding treatment modalities to your clinical practice is an important consideration. This webinar will provide you with key insights from Physiotherapist James Tomkies, looking at what are the key considerations, tools for success, and advice for both those looking to acquire new equipment, and also those looking to get more from their device.

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DOSING STRATEGIES

CLASS IV LASER THERAPY

Class IV laser therapy enables you to deliver a therapeutic dose of joules (J) to a larger area of target tissue in a shorter period of time as well as delivering adequate irradiance (W/cm^2) for deep tissue efficacy: ultimately resulting in positive, consistent, clinical results. Higher power and the option to deliver treatment in continuous wave give the clinician the flexibility to deliver the therapeutic dose of energy in less time than with other lower-powered devices. This technology is very effective at reducing pain and repair.

More specifically, analgesia that can be created at peripheral sensory nerves when higher irradiances are applied to C and A-delta sensory nerves. It has been shown that when > 270 mW/cm^2 is applied to these nerves, neuroplastic changes take place within 2-3 minutes at the peripheral nerve that slows the conduction rate of the pain signal[10]. This physical change to the nerve quickly reduces pain[11].

Additionally, it has been shown that an inhibition of nociceptive action potentials takes place when higher power densities are applied to nerve tissue. Specifically, a 30% neural blockade has been shown to start 10-20 min after treatment, which further reduces pain perception[11].

Check out our Interactive Return on Investment Calculator

Investing in new treatment modalities is a big step and can seem daunting due to high capital costs. Our interactive calculator provides estimated costs, and time to return your investment based on the number of patients per month, and treatment costs.

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WHAT DO THE LASER CLASSIFICATIONS ACTUALLY MEAN?

Class IIIb: IIIb lasers are hazardous to the eye when viewed directly. For visible and infrared devices, emission power is limited to 0.5W. Protective eyewear, key switches, and safety interlocks are required safety features.

Class IV: Class IV includes all lasers that emit powers in excess of the IIIB limitation of one half of one-watt. Eye protection is needed to limit both direct and diffuse reflected exposure. Key switches and safety interlocks are also required safety features. The majority of scientific, industrial, military, and surgical lasers are in this category. Furthermore, Lightforce Therapy devices are the only Class IV laser classified as 'low risk' according to the EU Medical devices classification

Power: Class IIIb lasers are limited to a maximum power of 0.5 watt. Class IV therapy lasers typically enable the user to select for powers greater than 0.5W, up to 40 watts. Increased power enables the clinician to treat a larger area in a shorter period of time, thus allowing a more efficient delivery of a therapeutic dose to target tissues.

Treatment Strategies: Due to their power differences, class IIIb and class IV laser treatment strategies vary. Class IIIb lasers are often used to treat single points or a group of small points and are held in one place for the duration of the treatment time at each point. When treating with a class IV therapy laser, the clinician may treat a much larger area, the treatment head is moved throughout the duration of the treatment to ensure a therapeutic dose of energy is being delivered evenly to the entire target area and its associated soft tissue structures. Class IV laser therapy can also be administered using contact or non-contact treatment heads.

Dosing Strategies: Relative to class IV lasers, class IIIb lasers are not able to deliver the same dose of energy to tissues without taking much more time. Further, these devices cannot achieve the higher irradiances needed for certain deep tissue conditions, especially chronic pain or musculoskeletal conditions. The foundation of class IV laser therapy is based on the delivery of a therapeutic dose of joules to a large area of target tissue, reducing variability in outcomes.

Wavelengths: Different therapeutic lasers often have different treatment wavelengths ranging from 700 nm to 1064 nm. All wavelengths in this therapeutic window target the same photo-active chromophores. The main difference between wavelengths is the absorption of the light by tissue components such as water and melanin.

TOP 9 BIOLOGICAL EFFECTS OF LASER THERAPY

DECREASED INFLAMMATION AND SWELLING
Laser therapy reduces inflammation through several mechanisms especially via the reduction of pro-inflammatory mediators. Facilitating lymphatic drainage can significantly reduce swelling as well. As a result, inflammation, erythema, bruising, and oedema are reduced.

ANALGESIC EFFECT
Laser therapy of diseased and damaged tissue produces a suppression of hypersensitive nociceptors, normalisation of the membrane firing threshold, and an increased release of tissue endorphins, amongst other mechanisms. In addition to the reduction in inflammation, the result is a decreased patient perception of pain.

ACCELERATED TISSUE REPAIR AND CELL GROWTH
Photons of light from lasers penetrate deeply into tissue and accelerate cellular reproduction and growth. Laser light increases the energy available to the cells so that they can take on nutrients and get rid of waste products more quickly.

IMPROVED VASCULAR ACTIVITY
Laser light significantly increases the formation of new capillaries in damaged tissue. This speeds the healing process, resulting in more rapid wound closure and improving blood supply to areas with poor circulation or chronic wounds.

TRIGGER POINTS AND ACUPUNCTURE POINTS
Laser therapy treats muscle trigger and acupuncture points without mechanical invasion to aid in providing musculoskeletal pain relief.

REDUCED FIBROUS TISSUE FORMATION
Laser therapy reduces the formation of fibrous scar tissue, favouring more appropriate deposition and orientation of collagen fibers leading to better tensile strength in
healed tissues.

IMPROVED NERVE FUNCTION
Slow recovery of nerve functions in damaged tissue may result in numbness and impaired limbs. Laser therapy accelerates nerve cell regeneration.

IMMUNOREGULATION
Therapy laser photons have an effect on the immune system's status through modulation of the immune response.

FASTER WOUND HEALING
Laser light stimulates fibroblast development. Fibroblasts produce collagen, which is predominant in wound healing in damaged tissue. Collagen is the essential protein required to replace old tissue or to repair tissue injuries. As a result, laser therapy is effective on open wounds and burns.

WHAT CAN LASER THERAPY TREAT?

LASER THERAPY: A POWERFUL ADJUNCT

Due to the drug-free, non-invasive nature of laser therapy it is often used as a powerful adjunct to existing treatment protocols. It can be used before, during, or after surgical procedures, alongside pharmacological management of certain conditions, and in conjunction with rehabilitation programs. Since laser therapy has a broad spectrum of physiological effects, mainly surrounding the reduction of pain and inflammation and increasing the speed of healing, it is a versatile tool as part of a multimodal approach to treating MANY common conditions in the medical field.

ACUTE CONDITIONS

Laser therapy has been shown to be effective to help treat acute conditions. Bringing pain under control quickly helps the healing process and usually helps promote better outcomes.

CHRONIC CONDITIONS

With chronic conditions, research has shown that therapy lasers can be used to help combat persistent pain and promote circulation to damaged tissues. It can be a powerful, non-pharmaceutical solution to help reduce pain without the side effects of medication. [10,12]

POST-ACTIVITY RECOVERY

LightForce® Therapy Lasers can be found on the sidelines of many pro, college, and Olympic sports teams across the United States and many parts of Europe and Asia. Laser therapy has been shown to be effective at improving post-activity recovery times and reducing delayed onset muscle soreness (DOMS)[13].

- TMJ [14,15]
- Neck Pain [16]
- Shoulder Pain [17,18,19]
- Elbow & Joint Pain [20]
- Fibromyalgia [21]
- Low Back Pain [22,23]
- Sciatica [12,24]
- Arthritis [25]
- Sports Injuries [26,27]
- Soft Tissue Damage [26]
- Plantar Fasciitis [5,28]

CASE STUDY

THIS CASE STUDY TAKE YOU THROUGH THE REAL-WORLD APPLICATION OF LIGHTFORCE LASER THERAPY AT HIVE HEALTH CLINIC IN SWANSEA, UNITED KINGDOM.

Q-1= CAN YOU SHARE WITH US THE SPECIFIC CHALLENGES OR CONDITIONS YOU WERE FACING IN YOUR CLINICAL PRACTICE THAT LED YOU TO CONSIDER LIGHTFORCE LASER THERAPY DEVICES?

The main driver was in managing acute pain cases (such as acute lower back muscle spasm), as well as extremity cases such as plantar fasciitis.

Q-2=HOW DID YOU FIRST LEARN ABOUT LIGHTFORCE LASER THERAPY DEVICES, AND WHAT MOTIVATED YOU TO PURCHASE THEM?

I'd heard via the British Chiropractic Association, and then had an email.

Q-3= WHAT WERE YOUR INITIAL IMPRESSIONS OF THE LIGHTFORCE LASER THERAPY DEVICES WHEN YOU FIRST ENCOUNTERED THEM?

Good sleek design, was impressed that it was quick and straightforward to use, and also felt pleasant - didn't hurt!

Q-4=CAN YOU DESCRIBE YOUR EXPERIENCE WITH THE PURCHASING PROCESS? WERE THERE ANY FEATURES OR BENEFITS THAT STOOD OUT TO YOU?

The payment process was quicker than we expected, the option to lease (via a different company) was very helpful

Q-5= COULD YOU DESCRIBE ANY SPECIFIC PATIENT CASES OR SCENARIOS WHERE YOU HAVE USED LIGHTFORCE LASER THERAPY DEVICES? WHAT WERE THE RESULTS?

We use it with the majority of our patients now, all with good results. One patient case that comes to mind is of shoulder pain - he couldn't raise his arm above less than shoulder height and was on the list for surgery After the second session he had full range of motion in the shoulders and has delayed the surgery. We had another patient with acute knee swelling which had completely resolved after the first session.

Q-6= IN WHAT WAYS HAS LIGHTFORCE LASER THERAPY DEVICES IMPACTED YOUR TREATMENT PROTOCOLS AND PATIENT OUTCOMES?

It means that we can better cater for the more acute patients, and extremity cases. We use it alongside standard chiropractic/osteopath treatment and find that the outcomes are being achieved a lot faster.

Q-7= HOW HAS THE INTEGRATION OF LIGHTFORCE LASER THERAPY DEVICES INTO YOUR PRACTICE AFFECTED YOUR WORKFLOW AND EFFICIENCY?

It's worked well - we've adjusted session times in some cases.

Q-8= HAVE YOU NOTICED ANY FINANCIAL OR BUSINESS BENEFITS SINCE INCORPORATING LIGHTFORCE LASER THERAPY DEVICES INTO YOUR PRACTICE?

It's generated a lot of new interest either from previously discharged patients or word-of-mouth.

Q-9= WHAT FEATURES OR ASPECTS OF LIGHTFORCE LASER THERAPY DEVICES DO YOU FIND MOST BENEFICIAL OR UNIQUE COMPARED TO OTHER SIMILAR PRODUCTS ON THE MARKET?

The on-contact head is a valuable addition as it is comfortable for the patient. The fact that it's comfortable to have done is a huge bonus over e.g. shockwave, and that it is quick is also a benefit over e.g. low level laser.

Q-10= HOW WOULD YOU SUMMARISE YOUR OVERALL EXPERIENCE WITH LIGHTFORCE LASER THERAPY DEVICES, AND WOULD YOU RECOMMEND IT TO OTHER CLINICIANS/PHYSIOTHERAPISTS?

Excellent - 100%

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