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REVIEW ARTICLE

Diode Lasers: A Versatile Clinical Tool (A Technical and Clinical Review)

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ABSTRACT

Diode lasers are fast becoming part of contemporary clinical practice and have since opened up vistas of unprecedented patient care. However, the nuances of their functioning and mechanisms of tissue interaction have not been widely discussed or clearly elucidated. This paper assimilates the facts in literature and throws light on the basics and essentials of this technological advancement that indeed has become a boon to all walks and branches of science.

Keywords: Diode lasers, Isosbestic point, Hemostasis, LLLT.

INTRODUCTION

Diode lasers have been a singular innovation and invention that has transformed scenarios in optical fiber based telecommunications, information technology and inevitably augmented and enhanced medical and dental practice. Theodore Maiman in 1960 (at Hughes research laboratory) heralded the birth of modern laser science with the epoch breakthrough of the Ruby laser (694 nm), but the first successful operation of diode laser was reported only in 1962 by several research groups (one of them being GE). Albeit the first emission of light by a semiconductor was by HJ Round in 1907 (Elect World 1907, 19:309) using the compound silicon carbide by the phenomenon of electroluminescence, Basov et al had suggested in 1961 that stimulated emission could occur in a semiconductor by the recombination of charge carriers across a p-n junction or homojunction diodes (Chow and Koch, semiconductor-laser fundamentals: Physics of the gain materials, Springer). Subsequent innovations saw the advent of the heterostructure/heterojunction diode laser in 1969 from the combined research of Herbert Kroemer and Zhores Alferov (Nobel Prize in 2000).[1]

SYNONYMS AND ADVANTAGES

As with any popular and universally accepted instrument or technology, the diode laser may be also termed variously as semiconductor lasers or laser diodes or injection lasers as opposed to the other solid state lasers which are termed pumping lasers as they have to be externally stimulated by a strobe lamp or a diode laser itself. They may also be termed as homojunction or heterojunction diodes depending on the type of semiconductor chip that serves as the lasing 'active' medium. The semiconductor chip itself could be surface emitting or edge emitting and could be termed likewise. Double heterostructure lasers, quantum well lasers, quantum cascade lasers, distributed feedback lasers, VCSEL (vertical-cavity surface-emitting laser) and VECSEL (vertical-external-cavity surface-emitting laser) are the more modern and latest versions of the diode laser.[1]

The diode lasers are semiconductor devices which operate from a standard AC electrical outlet with a relatively high power output. The external electrical power supply delivers the excitation required to facilitate stimulated emission and thus lasing. They have high electrical to optical efficiency, are small, lightweight and compact, hence, portable and are quiet devices as compared to the other solid-state and gas lasers (such as Nd YAG, KTP.YAG, Ho YAG, Argon, Erbium family and CO_2) which are bulky and difficult to transport, may have a warm-up time of several minutes and require a cooling system as well as requiring regular maintenance.[2] The diode lasers on the other hand are relatively maintenance free, reliability studies have shown a mean time to failure of 25,000 hours at maximum output power.[2]

DIVERSITY AND VARIATION

High power diode lasers are available over a wide range of wavelengths from 600 to 1060 nm. The wavelength of a diode laser is determined by the active compound used in the semiconductor. There are small but significant differences in the effects on tissue across these wavelengths due to the differing absorption properties of blood and the peak in the water absorption spectrum being at 975 nm.

Wavelength range (μm)	*Semiconductor alloy*	*Periodic group*
0.65-0.69	InGaAlP/AlGaAs	—
0.76-0.82	AlGaAs	III-V (NIR)
0.97-1.1	InGaAs	III-V (NIR)
1.1-1.8	InGaAsP	III-V (NIR)
2-4.5	AIGaAsSb/PbCdS	III-V (MIR)
3-30	PbTeSn	IV-VI (MIR)

Oxygenated blood absorbs light at 660 nm (red light), whereas deoxygenated blood absorbs light preferentially at 940 nm (infrared).[3]

This fundamental is used by finger pulse oximeters to measure the percentage of oxygen that is saturated within an individual's blood hemoglobin. One diode sends out red light while the other sends out infrared light. The relative absorption of light by oxyhemoglobin (HbO) and deoxyhemoglobin is processed by the device, and an oxygen saturation level is reported.

The 980 nm wavelength is near an absorption peak in the water spectrum (975 nm) (Fig. 2). The absorption coefficient of the 980 nm wavelength in water is about 20 times that of the 810 nm and three times that of the 1064 nm wavelength (MD Swick, A Richter); experimental work in chicken breast and bovine liver showed the ratio of the absorption coefficients of the 980 nm *vs* 1064 nm was 1:05.[2] Lasers operating at this wavelength absorb best in water, deoxygenated (venous) blood and in oxygenated blood.

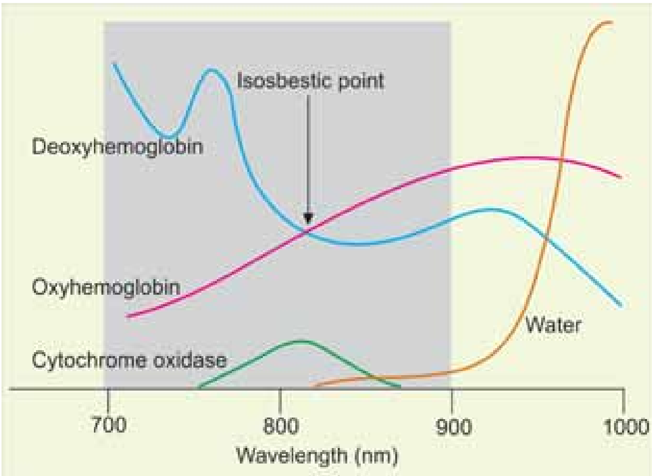

Fig. 1: Isosbestic point—at which total absorption of both deoxyhemoglobin and oxyhemoglobin occurs near 810 nm © *J Neuropsychiatry Clin Neurosci*

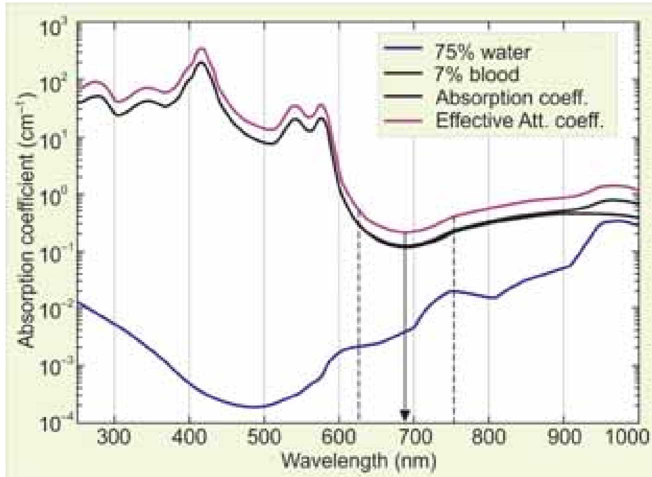

Fig. 2: Absorption curves for various wavelength

However, some wavelengths are equally sensitive to both (isosbestic points) (Fig. 1). At an isosbestic point, absorption is effected in total hemoglobin concentration (HbT). Oxyhemoglobin and deoxyhemoglobin have isosbestic points at 590 nm and near 800 nm.[4] The 810 nm diode laser wavelength is more heavily absorbed and is less penetrating than the 1064 nm Nd YAG wavelength in most tissues. The increased absorption of the 810 nm wavelength occurs principally in hemoglobin, in which it is 15 times more strongly absorbed than that of the 1064 nm wavelength. Jacques et al suggested that the 810 nm laser may be better for contact probe cutting of tissue and achieving hemostasis during such cutting because it is more strongly absorbed. Furthermore, Jacques et al performed an *in vitro* study in dog liver and found the absorption coefficient of 810 nm wavelength to be 3.5 times greater than that of the 1064 nm wavelength; the scattering coefficients were found to be similar, and the penetration of the 810 nm wavelength was found to be less than that of the 1064 nm by a factor of about 2.2 (mean penetration depths of 1.3 and 2.8 mm respectively).[2] However, in noncontact mode, the 810 nm laser provides relatively poor surgical precision when cutting or vaporizing soft tissue, because of several mm of collateral thermal injury resulting from soft tissue penetration and scattering and hence may be more appropriate for procedures which require photocoagulation and inducing photobiomodulation by stimulating cellular and humoral responses of the body.

At the 940 nm wavelength the diode laser is at the optimal, peak absorption in the spectrum for deoxyhemoglobin and, therefore, could be used to coagulate, cut or ablate soft tissue in contact mode and achieve hemostasis even in noncontact mode. Pulsed modes, such as Comfortpulse™, have been developed which allow a range of soft tissue procedures to be completed with just local anesthesia. This is thought to be possible by using very short pulse durations (such as 50-100 microseconds) which are shorter than both the thermal relaxation time of soft tissue and the receptor range for nociceptive pain responses.[5]

The analgesic effects of all these diode lasers have been attributed to a disruption in the action of the Na-K pump in the cell membrane, resulting in a loss of impulse conduction or simply due to an ablation of the nerve endings. Though there is some evidence that laser irradiation may selectively target fibers conducting at slow velocities, particularly afferent axons nociceptors.[5,6] This is an area of research actively and resolutely being pursued worldwide and by the IALD.

Internal Transmittance

Internal transmittance[7] refers to energy loss by absorption, whereas the total transmittance is that due to absorption, reflection, scatter, etc. The ratio of the transmitted radiant power ($P\lambda$) to that incident on the sample ($P\lambda o$):

$$T = P\lambda / P\lambda p$$

Laser optical delivery fibers have been mainly developed for the Nd:YAG laser at 1064 nm with high OH content quartz or silica having an internal transmittance of 99%. With these delivery fibers the 810 nm wavelength has a marginally better internal transmittance than 1064 nm; at 980 nm, the transmittance drops to about 70% and is a strong function of wavelength (Fig. 3).[8] Low OH content fibers too are now available with high transmittance and the difference in the kind of delivery fibers will have a bearing on the surgical effect and efficiency of the diode laser.

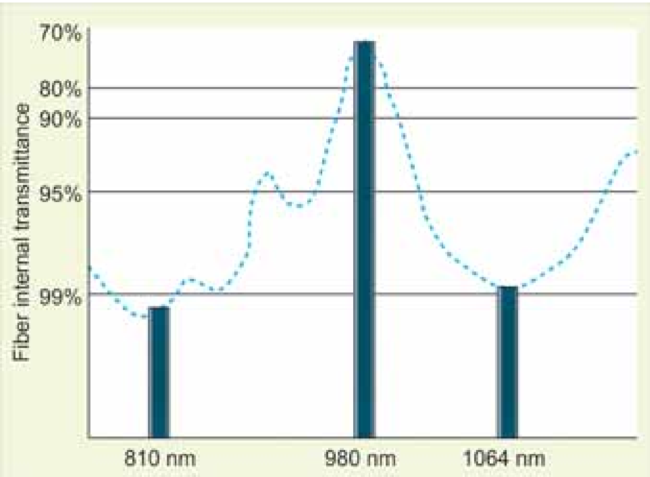

Fig. 3: Efficiency of delivering laser energy

Diode Laser versus Electrocautery

Patients, who have undergone a laser surgical procedure, such as vestibuloplasty, frenectomy or even a cosmetic procedure, such as depigmentation, report remarkably little or no intra-operative or postoperative pain or discomfort. Notably, few patients felt the need to take any analgesics postoperatively. The ablated surface or vaporized layer created by lasing serves as a scaffold for healing and as a wound dressing. It prevents bacterial infection of the wound surface (the laser itself being a sterilizing radiation) and seals blood vessels. Because of the latter, laser surgery reliably eliminates the risk of bacteremia. Thereby laser surgical wounds do not experience postoperative hemorrhage with little or no postoperative pain or discomfort, because of laser sealing of nerve endings.[9] The diode laser even in non-contact mode can give zero bacterial counts, as nothing but laser photonic energy comes in contact with the substrate tissue with no risk of any contamination of the surgical site.[5] In fact, it is a good practice to apply the laser in non contact mode after a surgical procedure, such as vestibuloplasty, frenectomy or even after an implant placement as it will provide biostimulation and hence speed up the healing process.[9]

Electrosurgery, as a means of cutting or ablating tissue, is a relatively archaic technique that is inherently inefficient, requiring high powers for tissue incision and pales in comparison to the diode laser which can achieve the same at considerably lower average power. Electrosurgical devices rely on the creation of an electric arc (between the treating electrode and the tissue that is being cut or ablated) to cause the desired localized heating. This desiccates the tissue, especially with repeated strokes of the electrode and when the tissue temperature reaches about 100°C, water vaporizes, dehydrating the tissue. This water loss causes the tissues' thermal properties to change; both the thermal conductivity and the diffusivity are reduced, and a rapid increase in temperature occurs before vaporization of the tissue. As a result, extremely high temperatures are created within the tissue mass to produce a clinical effect known as *fulguration*. This is because electrosurgery or electrocautery, is not absorption-specific within a target tissue and are unable to control the depth of necrosis in the tissue being treated. These high temperatures cause a depth of necrosis of more than 500 µm (often more than 800 µm and sometimes as high as 1,700 µm); the inability to control such depth of necrosis is a significant disadvantage to using electrosurgical techniques for tissue ablation. Conduction of current in oral fluids, metallic dental materials and metal instruments is also a well-recognized hazard with electrosurgery.[10]

On the other hand, lasers do not suffer from electrical shorting even in conductive environments. Lasers also allow for controlled cutting with limited depth of necrosis. This is due to their inherent ability to be absorbed within chromophores (wavelength specific light absorbing substances) within a specific target tissue and thus cause a tissue specific ablation, layer by layer and cell by cell.[10] This makes the laser surgery predictable with assured tissue healing as in gingival retraction procedures where restoration margins have to be established with optimal esthetics.

DIODE LASER WAVELENGTHS IN COMPARATIVE TISSUE EFFECTS AND CLINICAL TASKS

Effects on Root Surfaces

LH Theodoro and P Haypek compared the effect of the Er:YAG (100 mJ/10 Hz, 30 secs) and the 810 nm diode lasers (1.4 W, 0.05 ms, 30 secs) in their study designed to evaluate the morphological and thermal effects of teeth and found that the Er:YAG laser with water cooling in fact caused a decrease in intrapulpal temperature, but the diode laser, though caused a significant increase in temperature (1.6-3.3°C), it was well within the 5°C that could harm the pulp. The micromorphology of root surfaces treated with the Er:YAG laser is comparable to conventional treatment and conditioning with citric acid and EDTA which some authors say it improves the attachment of fibroblasts, whereas the 810 nm diode up to 1W did not cause any microscopic alterations, but at 1.4 W caused carbonization. They concluded that laser treatment could be expected to serve as an alternative or adjunctive to conventional mechanical periodontal treatment.[11]

Bergmans et al suggested that photoactivated disinfection (PAD) is not an alternative but a possible supplement to existing protocols for root canal disinfection as the interaction between laser light (diode laser, 635 nm, 100 mW, 150 secs. 15 J) and the associated dye (tolonium chloride, TBO) allows a broad-spectrum bactericidal effect. Some endodontic pathogens that grow as a multilayered (biofilm) structure, however, remain more difficult to eradicate. They recommended that to further optimize the potential of PAD, more research should be performed on the interaction among PAD, microbial specificity (especially in mixed microbiota) and biofilm disruption. However, this author feels that the laser parameters used though were too mild and minimal to effect the desired result.[12]

Gutknecht et al investigated that the antibacterial depth effect of continuous wave laser irradiation with a wavelength of 980 nm (1.75, 2.3 and 2.8 watt, CW) in the radicular dentin of bovine teeth and found that there was a 95% elimination of bacterial counts at 1.75 W, 96% at 2.3 W, and 97% at 2.8 W. Whereas on analysing sectional samples with a slice thickness of 300 µm, a maximum of 77% of the bacteria was destroyed at 1.75 W, 87% at 2.3 W and 89% at 2.8 W. The maximum bacterial reduction with a slice thickness of 500 µm was 57% at 1.75 W, 66% at 2.3 W and 86% at 2.8 W. They concluded that the 980 nm diode laser can eliminate bacteria that have immigrated deep into the dentin, thus being able to increase the success rate in endodontic therapy.[13]

Dentinal Hypersensitivity

The mechanism causing a reduction in hypersensitivity is mostly unknown but it is thought that the mechanism for each laser is different. In the case of low-power lasers (He-Ne and GaAlAs lasers), a small fraction of the laser's energy is transmitted through enamel or dentine to reach the pulp tissue (Watanabe et al, 1991, Watanabe, 1993). Kimura et al reported that the GaAlAs laser radiation at 830 nm has a pain suppressive effect by blocking the depolarization of C-fiber afferents (Wakabayashi et al, 1993). It has been suggested that He-Ne laser irradiation may affect the electric activity (action potential) and not affect peripheral A δ or C-fiber nociceptors (Rochkind et al, 1987, Jarvis et al, 1990). Parameters used for the treatment of dentinal hypersensitivity approximate 6 mW for 1 to 3 min and 30 mW for 0.5 to 3 mins. The effectiveness reported in literature say it could be up to 80 to 90%. Though, the most frequently applied wavelengths using the GaAlAs lasers were 780 nm (Matsumoto et al, 1985, Kawakami et al, 1989, Gerschman et al, 1994) and 830 nm (Hamachi et al, 1992, Mezawa et al, 1992). The pulpal effects of this type of lasers irradiation have been investigated.[12] The GaAlAs laser at a wavelength of 780 nm, and an output power of 30 mW for 3 minutes caused no damage to pulp tissues in monkeys (Matsumoto et al, 1985).[14] GaAlAs laser emissions at 904 nm have also been found to have an analgesic effect on the cat tongue although mechanisms remain unclear (Mezawa et al, 1988).[15]

Diode Lasers in Implantology

Diode lasers are widely used in second stage implant surgery in the uncovering of implants. They are preferred due to the bloodless field. They are able to provide exceptional and faster healing, patient acceptance due to a painless experience and more importantly the convenience that impressions can be made immediately and assuredly with no change in the emergence profile by any tissue shrinkage or recession.

Haas R, Dortbudak O et al used a 905 nm laser in CW for 60 secs in association with Toludene blue for photosensitization of implant surfaces and found it led to the elimination of *A. actinomycetemcomitans and P. intermedia* and *P. gingivalis*[16]. An *in vitro* study with different implant surfaces (Romanos GE, Everts) has shown that the 980 nm diode lasers using high-power settings (10 W) do not damage titanium surface texture.[17]

Further, clinical indications for diode laser can be the removal of peri-implant overgrowths as well as the decontamination of implant surfaces before augmentative surgical procedures; however, the use of a diode laser with an 810 nm wavelength in a high-power setting adversely changes the implant surface, and, for that reason, such lasers have to be applied with special care in order to treat peri-implantitis efficiently.[18] High-power diode lasers (810 nm) may have excellent coagulation properties but are similar to those of the Nd:YAG laser characterized by superficial tissue absorption with penetration to the underlying tissues.

Laser Bleaching

There are serious concerns about the safety of conventional bleaching process using hydrogen peroxide-containing bleaching products. Alterations of the surface texture of enamel, including shallow depressions, increased porosity and slight erosion, have been reported via the use of scanning electron microscopy. The prism layers to the depth of the enamel rods have been reported to expose and possibly even extend into the dentin.[19] Patients also have complained about immediate postoperative dentinal sensitivity that in some cases continues to even later.

T Dostalova et al in their study found that selective diode laser radiation can decrease the time of bleaching without surface modification. The 970 nm diode laser and the bleaching agent produced the same effect but with a shorter time of bleaching process (5 mins-1 W, 2.5 mins-2 W). The 790 nm red diode laser used along with the blue light emission diodes of 467 nm wavelength, and the bleaching agent reached the desired color shade also after a shorter time (5 mins-40 mW). They postulated that diode lasers can positively contribute to the field of tooth bleaching.[20]

K Goharkhay, U Schoop, A Moritz et al evaluated the corrosiveness of enamel surfaces with Smartbleach®, Opus White®, Opalescence Xtra Boost® and a gel containing titanium dioxide (TiO_2) particles, activated either by a frequency doubled neodymium: Yttrium-aluminium-garnet (Nd:YAG) laser (532 nm) or a diode laser (810 nm), using environmental scanning electron microscopy (ESEM). The changes in teeth color shades were evaluated using a colorimeter and the pH were also evaluated using a pH meter to cross check the manufacturer's claims. Each bleaching agent was laser activated for 30 seconds and removed after 1 min or 10 mins. As this procedure was repeated up to four times, the bleaching agent receiving a maximum application time of 40 mins, with total irradiation times of 0.5 mins to 2 mins of laser activation. The results of the pH measurements showed that only Smartbleach® was in the alkaline pH range, whereas the other three were acidic. The surface effects were unrelated to the pH of the bleaching agents. With the exception of Opus White®, no severe alterations on the enamel surface were detected. Although short application times were chosen, improved changes in brightness of up to ten steps on the Vitapan® classical shade guide were detected. Intrapulpal temperature measurements revealed no temperature increase in the pulp chamber when Opalescence Xtra Boost 38%® was irradiated with 810 nm, 1W, for 60 seconds. However, the control samples irradiated without gel application showed a 5°C increase. The values for 2 W and 60 seconds of irradiation time were 2.8°C and 9.6°C respectively. They concluded that laser-activated bleaching offers an improvement in terms of effectiveness and enamel surface protection.[19]

Currently, the laser has been proven to be the most valuable energy source for power bleaching with simple and short application time in the office and provides life time immunity to caries and acidic environs in the oral cavity by effecting microcrystalline changes within it, thus lowering the critical pH of enamel from 5.51 to 4.31.

Interstitial Laser Therapy

Prostrate: The advantage of laser surgery in comparison with that of TURP (transurethral resection of prostrate) in the treatment of benign prostatic enlargement is almost bloodless and also the absence of fluid absorption (TUR syndrome). For the TURP procedure, complications are seen up to 20% of patients following a successful intervention. The wavelength of 980 nm with the highest simultaneous absorption in water and hemoglobin has been confirmed to be the most widely used.[21] This diode laser is able to combine very high tissue ablation properties with the benefit of excellent hemostasis due to deep coagulation. Diode laser energy at this wavelength is absorbed by water and hemoglobin, resulting in high ablation capacity and deep coagulation, whereas the KTP laser energy is predominantly absorbed by hemoglobin, resulting in lower ablation and coagulation. The diode laser showed a two to threefold increase in efficiency in removal of tissue, in the side-fire technique, in comparison with the KTP laser device. This could overcome the aspect of the procedure being time-consuming. At the same time, they concluded that due to the deep coagulation rim achieved beyond 7 mm in the porcine kidney model and 3.5 to 7.9 mm in the human cadaver prostate, excellent hemostasis could be guaranteed.[22]

Laser lipolysis is a relatively new technique and still under development. The Nd:YAG laser was first proposed for use in laser lipolysis because of the penetration depth of its wavelength (1064 nm). However, diode lasers, which can typically emit at 810 nm, 940 nm and 980 nm, could offer an alternative. Their wavelengths are in the same spectral region and they offer the advantages of higher efficiency (usually 30%) and higher power (25 W or more). The absorption spectrum of mammalian fat obtained by van Veen et al using three independent methods show that the absorption coefficient obtained with a wavelength of 980 nm (0.02 cm^{-1}) is very similar to that obtained with a wavelength of 1064 nm (0.04 cm^{-1}). Correspondingly, coefficients of human fatty tissue reported by Altshuler et al were found to be very similar. Moreover, Conway et al using a new method for the estimation of body composition in human beings, reported a similar optical absorption coefficient in the 900 to 1100 nm spectral band. The interaction of the laser with the tissue is similar at 980 nm and 1064 nm with the same energy settings. They reported that since higher volumes of fat are removed with higher total energy, high-power 980 nm diode lasers could offer an interesting alternative to the 1064 nm Nd:YAG laser.[23]

Tissue Soldering

ME Khosroshahi, MS Nourbakhsh et al demonstrated that the use of endogenous and exogenous materials, such as indocyanine green (ICG) (added to solders to enhance light absorption) and protein solder of 60% bovine serum albumin in conjunction with the 810 nm diode laser in continuous wave (CW) at an irradiance of 47 W/cm^2 for skin tissue soldering. However, they cautioned that laser soldering yet could have three main drawbacks to laser welding: (a) The immediate tensile strength during the first few days is low, (b) there is often noticeable thermal damage, (c) the results are frequently inconsistent.[24]

Biostimulation or Low Level Laser Therapy

Absorption of the photonic energy of near-infrared (NIR) light by tissues has been shown to be therapeutic for the reduction of pain, inflammation and edema, promoting the healing of wounds, deeper tissues and nerves and preventing tissue damage. This is termed as Low-level laser therapy (LLLT), the reason being that the levels of energy density delivered are low (mW) when compared to other forms of laser therapy as practiced for ablation, cutting and thermally coagulating tissue. It enhances remodelling and repair of bone , and even modulates the immune system through a stimulatory effect producing metabolic, physiologic and biochemical changes within the body, like the release of growth factors, such as bFGF, IGF and VEGF, a reduced secretion of PGE2, IL-1 and the local release NO. It stimulates the cellular respiratory chain within membranes of the mitochondria and speeds up production of ATP and thereby expedites the normal functions of the cell.[25] Following LLLT, neural tissues show reduced synthesis of inflammatory mediators as well as more rapid maturation and regeneration. LLLT has also been proven to reduce pain in patients suffering from postherpetic neuralgia, from cervical dentinal hypersensitivity, or from periodontal pain during orthodontic tooth movement. LLLT is also of utmost benefit in treating TMJ disorders.[6]

This phenomenon is surmised by T Karu, M Hamblin et al to be a consequence of an “Optical window” in the absorption spectrum of tissue due to reduced absorption of red and NIR wavelengths (600-1200 nm) by tissue chromophores such as melanin and hemoglobin (near 600 nm) and water (975-1200). Hence, the photonic energy of the laser light is effective directly on cellular organelles achieving effective penetration. Karu suggested the following wavelength ranges for four peaks in the LLLT action spectrum: (1) 613.5-623.5 nm, (2) 667.5-683.7 nm, (3) 750.7-772.3 nm, (4) 812.5-846.0 nm.[25]

In 2002, MicroLight Corp received 510K FDA clearance for the ML 830 nm diode laser for the treatment of carpal tunnel syndrome. There were several controlled trials reporting significant improvement of pain and some improvement in objective outcome measures. Studies from Whelan’s group have explored the use of 670 nm diodes in combating neuronal damage caused by neurotoxins, such as methanol intoxication, three brief 670 nm diode treatments (4 J/cm^2), delivered at 5, 25 and 50 hours of methanol intoxication, attenuated the retinotoxic effects of methanol-derived formate.[25]

Byrnes et al used 1,600 J/cm^2 of 810 nm diode laser to improve healing and functionality in a T9 dorsal hemisection of the spinal cord in rats. Anders et al studied LLLT for regenerating crushed rat facial nerves, by comparing 361, 457, 514, 633, 720 and 1064 nm, and found the best response with 162.4 J/cm^2 of 633 nm He-Ne laser.[26]

Laser Parameters

Any new technology requires a learning curve before one reaches proficiency and acceptance. The laser is definitely a double-edged sword and careful and judicious use of laser parameters, such as power density, the total power delivered over a given surface area (energy density or fluence), pulse duration, pulse width, frequency, spot size, as dependent on fiber or tip diameter, and the decision on whether to use the laser in continuous wave or pulsed mode is equally important as it decides the rate and duration of exposure (continuous versus pulsed, pulse duration and repetition). In the case, the tissues require thermal relaxation as in the case the surgical site being extensive then a pulsed mode may be mandatory, so also the method by which energy is delivered to the target tissue (contact versus non-contact) is also important. In fact, clinicians will have precise control over the laser to achieve the desired tissue effect by adjusting any of four variables *viz* power, spot size, total treatment time and repetition rate. Of all these parameters, the extent of exposure time is paramount and is the deciding factor between a clean, precise surgical ablation and charring (Markholf Niemz 2007). Most laser excisional or incisional procedures should be accomplished at 100°C or below, where vaporization of intra and extracellular water causes ablation or removes biological tissue. Clinicians must be wary of the heat generated within tissues during procedure and allow for thermal relaxation. This would also depend on the tissue characteristics and the wavelength of the diode laser being used and the nature of its absorption in the chromophores present. If the tissue temperature exceeds 200°C during a lasing procedure, carbonization and irreversible tissue necrosis will occur.[27]

CONCLUSION

Diode lasers are equal to the task for a myriad of clinical procedures. Their varied applications have found acceptance in diverse fields of medicine, dentistry and technology. Yet further research is warranted and much enigma remains about its exceptional effects on healing and painlessness. Nevertheless, it definitely is not a leap in the dark and is a science learned through experience and based on evidence. Let us in the scientific community savor, its unique advantages yet open our minds to a future of unending possibilities in the realm of light.

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