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FUNDAMENTALS AND LASER-TISSUE INTERACTION PHYSICS IN DENTISTRY

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ABSTRACT

The scientific literature regarding dental application for laser is increasing. The past decade has seen a veritable explosion of research into the clinical applications of lasers in dental practice. Once regarded as a complex technology with limited uses in clinical dentistry, has grown with its awareness and usefulness in the armamentarium of the modern dental practice. They have been used as an adjunct or alternative to the traditional approaches. Since, the development of the ruby laser by Maimam in 1960, a variety of papers on potential application of lasers in dentistry have been published. Various, and at times conflicting, claims by manufacturers, scientists and clinicians fill dental meetings and journals. The purpose of this paper is to review the general principles of lasers including their properties, components and physics behind laser tissue interaction. With the potential availability of many new laser wave lengths and modes, much interest is developing in this promising dental field.

INTRODUCTION

Laser is one of the most significant contributions of last century to science. In 1917, Einstein also predicted Zur Theorie der Strahlung (Theory of wavelength) that when there is population inversion between upper & lower energy levels among the atom system it was possible to realize amplified stimulated radiation i.e. Laser light. Einstein called this process Stimulated Emission of Light, which is the back bone of laser [1].

The theoretical basis of laser light production was developed some 90 years ago, the first laser was used on extracted tooth 47 years ago [2]. It is perhaps somewhat surprising that commercially available lasers lave been used in dental practice during the past 18 years. Associated with the launch of the ‘first’ dental laser, there was a level of type that quickly led to a combination of frustration for dentists and research that discredited or minimized many of the claims for clinical use [2].

In dentistry the use of laser is considered adjunctive in delivering a stage of tissue management conductive to achieving a completed hard or soft tissue procedure [2]. Theodore H. Mainman had exposed an extracted tooth to his Ruby laser in 1960 [3]. However, in 1964 Stern and Sogannes began looking at the possible uses of Ruby laser in dentistry. They began their laser studies on hard dental tissue by investigation the possible uses of ruby laser to reduce sub-surface demineralization [3].

In 1965, Goldman was the first to irradiate the surface of tooth intra orally. He called this “superficial oblation that was not painful to the patient.” He also studied the effects of pulsed laser on human caries [1]. The results of the study showed that effects varied from small 2 mm deep holes to complete disappearance of carious tissue with some whitening of surrounding sum of enamel, indicating extensive destruction of carious areas, along with crater formation and melting of dentine [1].

CO$_2$ laser was the first laser to receive FDA clearance for oral use in 1976. The commercial availability of laser for dental applications began in 1989 under the name ‘American Dental Laser’ [2]. This laser using an active medium of Nd: YAG emitted pulsed light and was developed & marketed by Terry Myers, an American dentist. Though low powered and due to its emission wavelength inappropriate for use on dental hard tissue, the availability of a dedicated laser for oral use gained popularity among dentists. This laser was first sold in U.K. in 1990 [2].

Other laser wavelengths using machines that were already in use in medicine & surgery and only slightly modified became available for dental use in early 1990’s Being predominantly Argon, Nd : YAG, CO$_2$ semiconductor diodes, all these laser failed to address a growing need amongst dentists and patients for a laser that would ablate dental hard tissue [2].

In 1989, experimental work by Keller and Hibst using a pulsed Erbium YAG (2,940 mm) laser, demonstrated its effectiveness in cutting enamel, dentin & bone. This laser became commercially available in U.K. in 1995 and was shortly followed by a similar Er. Cr: YSGG (Erbium, Chromium: Yttrium Scandium Gallium Garnet) laser in 1997, amounted to laser armamentarium that would address the surgical needs of clinical dentistry in general practice [2].

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Essentially, the use of adjunctive surgical laser in dentistry has sought to address efficient cutting of dental hard tissue, haemostatic ablation of soft tissue and also sterilizing effect through bacterial elimination. Less powerful, non – surgical lasers have been shown to modify cellular activity and enhance biomechanical pathways associated with tissue healing [3].

The decision to include laser in everyday dental care will depend not only on financial consideration, as to how their use enhances practice profitability, the greatest factor in making that decision will be an understanding of now laser wavelength interact with oral tissue, together with an appreciation of now their use can improve patient management [3].

Laser Physics

The word LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. These words offer an understanding of basic principles of how a laser operates [4].

Light – Light is a form of electromagnetic energy that behaves as a particle & a wave. The basic unit of this energy is called a photon [4].

There are 3 measurements that can define the wave of photons produced by a laser. The first is velocity which is the speed of light. The second is amplitude, which is the total height of wave oscillation from the top of peak to the bottom on vertical axis. This is an indication of the amount of intensity in the wave: the larger the amplitude the greater the amount of useful work which can be performed. The third property is wavelength, which is the distance between any two corresponding points on wave on the horizontal axis. This is a measurement of physical size which is important in determining how the laser light is delivered to the surgical site and how it reacts with the tissue [4]. Frequency is inversely proportional to wavelength; the shorter the wavelength the higher the frequency and vice- versa.

Amplification: Amplification is a process which occurs inside the laser, with the help of various components. An optical /laser cavity is at the center of device. The core of the cavity is comprised of chemical elements, molecules or compounds and is called the active medium/gain medium. Laser are generically named for the material of active medium, which can be a container of gas, a crystal or a solid – state semiconductor [4]. The active medium is positioned with in the laser cavity, an internally polished tube with mirrors, one at each end of the optical cavity, placed parallel to each other & surrounded by external energizing input: pumping mechanism/excitation mechanism, either a flash lamp strobe device or an electrical coil which provides the energy to the active medium. A cooling system, focusing lens completes the basic components [4].

Optical Resonator*:* It plays a very important role in the generation of laser, in producing high directionality to the laser & to overcome the losses due to straying away of photons from laser medium. This is achieved by bounding the laser medium between 2 mirrors. On end is high reflectance mirror (100% reflecting) or REAR MIRROR and on other end are partially reflecting/transmissive mirrors also called the OUTPUT COUPLER. And it is this output coupler from which the laser bean emanates [4].

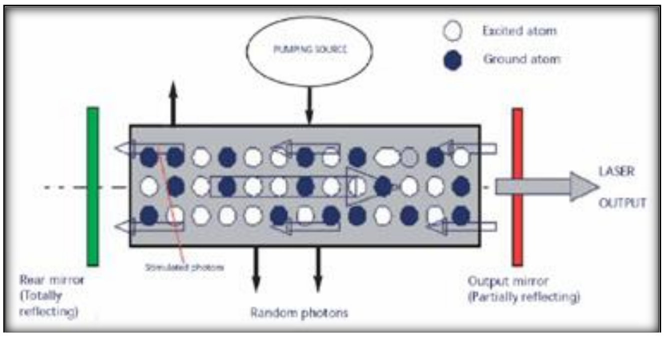


Figure 1 Schematic presentation of optical resonator

Stimulated Emission: The term stimulated emission has its basis in the quantum theory of physics, introduced in 1900 by the German physicist MAX PLANCK and further conceptualized to atomic architecture by NIELS BOHR, a physicist from Denmark. A quantum, the smallest unit of energy, is absorbed by the electrons of an atom or molecule causing a brief excitation; then a quantum is released, a process called 'spontaneous emission'. This quantum emission, also termed a photon can be of various wavelengths because there are several electron orbits [4].

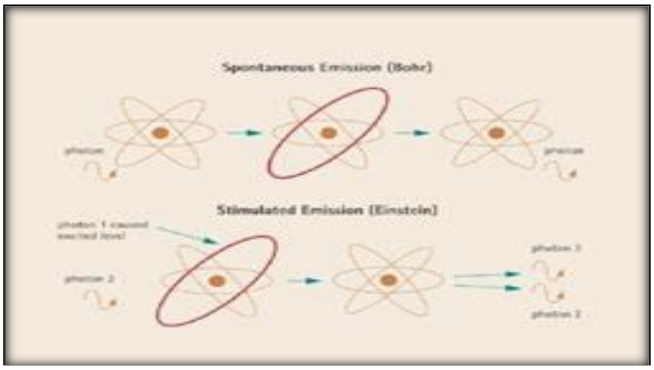


Figure 2 Schematic presentation of Stimulated Emission

SIR ALBERT EINSTEIN proposed that an additional quantum of energy traveling in the field of excited atom that has the same excitation energy level would result in a release of 2 quanta, a phenomenon he termed as 'stimulated emission'. This process occurs just before the atom could undergo spontaneous emission. The energy is emitted, radiated as 2 identical photons, traveling as a coherent wave. The mirrors at each end of the active medium reflect these photons back & forth to allow further stimulated emission and successive passes increases the power of the photon beam. This is the process of amplification [4].

Radiation: Radiation refers to the light waves produce by the laser as a specific from of electromagnetic energy. The electromagnetic spectrum is the entire collection of wave energy ranging from γ- rays to radio waves whose wavelength can be thousands of meters. The very short wavelengths, those below approximately 300 nm are termed as Ionizing. This term refers to the fact that higher frequency radiation has a large photon momentum, measured in electron volts/photon. Wavelengths larger than 300 nm have less photon energy and cause excitation and heating of tissues with which they interact. All dental longest wavelength [5]. It has a wavelength between 750 nm and 1 mm. Humans at normal body temperature can radiate wavelengths of 10 micrometers [5].

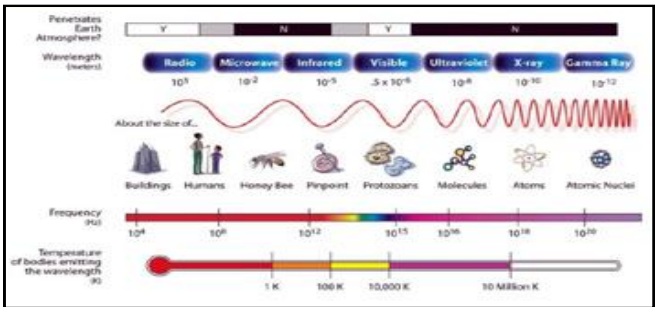


Figure 3 Electromagnetic Spectrum

Produced by molecular vibrations and rotations i.e. heat and causes such motions in molecules of object that absorb it. Infrared band is divided into smaller section: -

1.Far Infrared – (25 to 40) to (250-300) µm
2.Mid- Infrared - 5 to (25 - 40) µm
3.Near -infrared – (0.7-1) to 5 µm.

The visible spectrum also known as optical spectrum is the portion is the portion of electromagnetic spectrum that is visible to human eye electromagnetic radiation in this range of wavelength is termed as visible light or simply light [5]. A typical human eye responds to a wavelength in the range of 380 to 750 nm.

Table 1 Visible Spectrum Wavelength

Colour	Wavelength (nm)
Violet	380-450
Blue	450-495
Green	495-570
Yellow	570-590
Orange	590-620
Red	620-750

Ultraviolet radiation is electromagnetic radiation with a wavelength shorter than that of visible light, but longer than x-rays. It is named so because the spectrum consists of electromagnetic waves with frequencies higher than those humans identify as colour "violet [5]. The electromagnetic spectrum of U.V. light can be subdivided by a number of ways.

Table 2 Electromagnetic Radiation Wavelength

Name	Wavelength (nm)
1.Ultraviolet a (long wave)	400-315
Near	400-300
2.Ultraviolet B (Medium wave)	315-280
Middle	300-200
3.Ultraviolet C (Long wave)	280-100
For	200-122
Extreme	121-10

The choice of an appropriate wavelength involves a combination of known tissue effect and operators clinical experience.

Laser Delivery Systems

Dependent upon emitted wavelength the delivery system may be quartz fiber-optic flexible hollow wave guide, an articulated arm (incorporating mirrors) or a hand piece containing laser unit (for low powered lasers) [2].

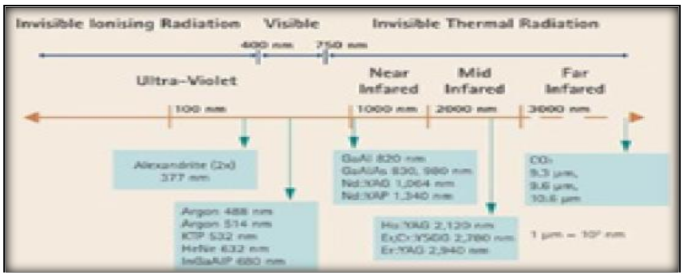


Figure 4 Laser wavelengths commonly used in clinical dentistry

Articulated Arm

Before the introduction of Nd: YAG laser in 1990, most dental lasers used bulky articulated arm for their delivery system. It consists of a series of hollow tubes with mirrors at each joint (called a knuckle) that reflect the energy down the length of tube. This joint allows the delivery arm to be bent in such a way as to bring the hand piece close to the target tissue. The laser energy exits the tube through the hand piece. Most commonly used with CO_2 laser [6].

Waveguide

Waveguide is a single, long semi flexible tube without knuckles or mirrors. It consists of an inner reflective lumen along which the laser energy is transmitted and exits through a hand piece at the end of the tube which can be used either in contact or non – contact mode. Two types of waveguides which are used commonly with lasers: Planar and Channel waveguides. Planar waveguides guide light only in vertical dimension as in for laser induced breakdown spectroscopy, whereas channel waveguides guide light in 2 dimensions. Used for conducting large wavelength lasers like CO_2 lasers [6].

Optical Fibers

The American Dental Laser Nd: YAG system was the first such instrument to use a fiber optic delivery system. This fiber optic technology allows for contact with the target tissue. The fiber optic cables are attached to a small hand piece similar in size to a dental turbine and are available in sizes ranging from 200 µm in diameter to 1000 µm in diameter. Fiber optic cables also are relatively flexible. This flexibility allows for easy transmission of the laser energy throughout the oral cavity, including into periodontal pockets. Laser light can be delivered by an optical fiber, which is frequently used with near infrared and visible lasers. Most commonly made of glass i.e. silica.

The light is trapped in the glass and propagates down through the fiber in a process called total internal reflection. Used for: Argon, Diode, and Nd: YAG lasers. The final delivery system is the Air-cooled fiber optic delivery system [6]. This type of delivery system is unique to the Erbium family of lasers. A conventional fiber optic delivery system cannot transmit the wavelength of the erbium family of lasers, owing to the specific characteristics of the erbium wavelength.

These special air-cooled fibers terminate in a hand piece with quartz or sapphire tips. These tips are used slightly (1–2 mm) out of contact with the target tissue. Once the laser is produced, its output power may be delivered in the following modes.

1. ***Continuous wave:*** When laser machine is set in a continuous wave mode the amplitude of the output beam is expressed in terms of watts. In this mode the laser

emits radiation continuously at a constant power levels of 10 to 100 W. Eg. CO_2 laser

Figure 5 Fiberoptic cables of various diameters and handpieces from a CO2 waveguide delivery system. (Courtesy of Robert Convissar, DDS, New York, NY.)

Figure 6 Quartz fiber

Figure 7 Articulated arm

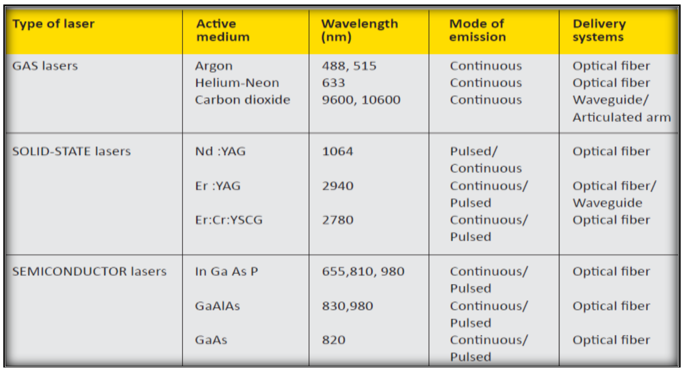
Figure 8 Hollow waveguides

2. **Chopped:** The output of a continuous wave can be interrupted by a shutter that "chops" the beam into trains of short pulses. The speed of the shutter is 100 to 500 ms.
3. **Gated:** The term super pulsed is used to describe the output of a gated high peak power laser with short pulse duration, typically between hundreds of microseconds (1ms = 1x10-6 sec.). The pulse produced during super pulsing can have a repetition rate of 50 to 250 pulses per second that permits the laser output to appear almost continuous during use.
4. **Pulsed:** Lasers can be gated or pulsed electronically. This type of gating permits the duration of the pulses to be compressed producing a corresponding increase in peak power, that is much higher than in commonly available continuous wave mode.
5. **Super pulsed:** The duration of pulse is one hundredth of microseconds.
6. **Ultra pulsed:** This mode produces an output pulse of high peak power that is maintained for a longer time and delivers more energy in each pulse than in the super pulsed mode. The duration of the ultra-pulse is slightly less.
7. **Q-switched:** Even shorter and more intense pulse can be obtained with this mode. Several hundreds of mili joules of energy can be squeezed into nano second pulses.
8. **Flash-Lamp pulsing:** In these systems, a flash – lamp is used to pump the lasing medium, usually for solid state lasers.

Laser Operating Parameters[7]

All the laser instruments used in dentistry feature parameters that are adjustable by the clinician these are:

Table 3 Various Lasers Parameters



Type of laser	Active medium	Wavelength (nm)	Mode of emission	Delivery systems
GAS lasers	Argon Helium-Neon Carbon dioxide	488, 515 633 9600, 10600	Continuous Continuous Continuous	Optical fiber Optical fiber Waveguide/ Articulated arm
SOLID-STATE lasers	Nd :YAG Er :YAG Er:Cr:YSCG	1064 2940 2780	Pulsed/ Continuous Continuous/ Pulsed Continuous/ Pulsed	Optical fiber Optical fiber/ Waveguide Optical fiber
SEMICONDUCTOR lasers	In Ga As P GaAlAs GaAs	655,810, 980 830,980 820	Continuous/ Pulsed Continuous/ Pulsed Continuous/ Pulsed	Optical fiber Optical fiber Optical fiber

Energy is the ability to perform work & is expressed as joules or milli joules.

Energy = Force × Distance

Power is the measurement of work completed over time & is measured in watts.

{ 1 watt = 1 Joule/second }

Average power is the power that affects the tissue on a sustained basis over a period of time.

Pulse duration/pulse width is the total time that a beam is continuously producing output. This time period determines the nature of 'true' pulsed laser versus gated system.

Repetition rate The number of times during a given interval, that a beam is producing output onto a largest. This parameter is usually measured in number of time/second that a beam produces output. Cycles per second/hertz (Hz) are also synonyms.

Power density is the inherent power in the beam. Also known as irradiance, which is the amount of power/unit area. This parameter includes the nature of spot size, amplitude of wave & the specific wavelength involved.

$$\textbf{Irradiance} = \frac{\textbf{Power}}{\textbf{Area}}$$

Energy density is the sum total of fluent energy delivered to tissue from a direct source. It is also known as fluence, which is the irradiance multiplied by exposure time, measured in joules/square centimeter. Fluence or energy density determines the magnitude of laser interaction.

$$\textbf{Fluence} = \frac{\textbf{Pulse Energy}}{\textbf{Area of spot size}}$$

Beam diameter Lenses within the laser instrument focuses the beam. A beam of light incident, on the tissue may be reflected, absorbed/scattered. Scattering in the tissue broadens the incident beam, decreasing the effective fluence in the intended target area. Doubling the spot size will increase the effective volume by a factor of eight. A large spot size usually enables faster & more effective treatment as in haemostasis. As a general rule, doubling the spot size & having fluence will yield an effective fluence at a given depth. This effect becomes more pronounced with increasing depth [7].

***Mode of Contact With Tissues*:** (Relation of tip of delivery hand piece with tissue) [8]

Contact mode: Tip of hand piece in contact with target tissue.

1. Increased tactile sensation
2. Increased access.
3. Focal point at or very near to the tip of delivery system.
4. Used mainly with fiber optic cable, for sharp incision or excisions.

Non-contact mode: Delivery tip at some distance from the target tissue.

1. Decreased tactile sensation
2. Access problem
3. Focal point at some distance farther from tip.
4. Used mainly with hollow wave-guide for following tissue contours.

Beyond the focal point, the beam diverges and its power density and intensity decreases. When working on a tissue, the beam should always be used either with the focal point positioned at tissue surface (Focused) or positioned above tissue surface (Defocused). The lasers should never be positioned with focal point deep or within the tissue (Pre-focused) as it can lead to deep thermal damage and undesirable tissue effects. An important principal in any laser emission mode in that the light energy strikes the tissue for certain length of time, producing a thermal interaction. In the pulsed mode the target tissue has the time to cool off before next pulse. But in continuous wave mode operators must cease the laser emission manually to allow thermal relaxation.

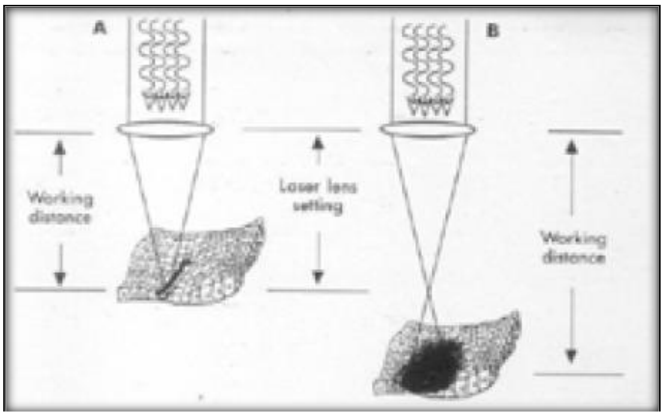


Figure 9 A. Laser-tissue interaction when the tissue is the focal distance away from the lens, Note the minimum beam diameter in the focal plane.
B. Laser-tissue interaction when the tissue is not in the focal plane of the lens. The laser covers a much larger area on the tissue surface.

Characteristics (Properties) of Laser Light[8]

The significant feature of laser is the enormous difference between the character of its light and light from other sources such as sun, a flame or an incandescent lamp.

The most striking features of lasers are its

1. Coherence
2. Monochromacity
3. Brightness & intensity
2. Directionality
3. Collimation
4. Focusability

Coherence

Laser light is said to be coherent which means wavelength of laser light are in phase of space and time i.e. synchronized phase of light waves. Coherence can be spatial or temporal [8,9].

Monochromatic

Monochromatic refers to single wavelength (color) of laser beam. Ordinary white is a mixture of color as you can demonstrate by shining sunlight through a prism. Because the wavelength of laser light determines its effects on tissues; monochromatic property of laser light allows energy delivered to specific tissues in a specific way. Thus, laser are often defined by their visible color (eg: red light / green light laser), by their position in the electromagnetic spectrum (eg: infrared, ultraviolet or x-ray lasers) or by chemicals that create light (e.g.: CO_2, Argon or Nd: YAG lasers) [8,9].

Brightness & Intensity

It is related to output power & beam quality of laser. All the properties of laser together produce a very intense & powerful flash or beam of light[8,9].

Directionality

Laser light is highly directional laser light is emitted as a relatively narrow beam in a specific direction whereas; ordinary light is emitted in many directions away from the source[8,9].

Collimation

Collimation refers to parallel nature of laser beam. Laser light is emitted in a very thin beam with all light rays parallel to each other [8]. All laser beams are parallel / collimated unlike regular light. Because the laser beam does not diverge significantly over distance, the source can be positioned at great length from target tissue or can be very efficiently focused down to a small spot with a convex focusing lens. Most solid – state lasers naturally emit collimated beams.

Focusability

Lasers work on the principle of stimulated emission of photons. These photons are released from their environment from first very small opening, because of the manner in which laser light is achieved it becomes highly focused, thus making lasers useful for specialized applications that require accuracy [8,9].

Laser-Tissue Interaction

When electronic energy (incident radiation) interacts with tissue, the tissue reflects part, the tissue absorbs part, and the tissue transmits and scatters part of the light. The surgical interaction of this radiant energy with tissue is caused only by that portion of the light that is absorbed, that is the incident radiation minus the sum of the reflected and transmitted portions (Polanyi 1983) [10].

Laser light can have 4 different interactions with the target tissue depending on the optical properties of that tissue. Dental structures have complex composition and these 4 phenomenon's occur together in some degree relative to each other [11].

The first and the most desired interaction is the absorption of the laser energy by the intended tissue. The amount of energy that is absorbed by the tissue depends on tissue characteristics, such as pigmentation and water content and on the laser wavelength and emission mode [11].

The main absorbing components or chromophores (tissue compounds) of tissue are:

1. Water (present in all the biologic tissues)
2. Hemoglobin in blood
3. Melanin of skin, hair
4. Protein and other macromolecules hemoglobin, the molecule that transports oxygen to tissue, reflects red wavelength imparting colour to the arterial blood. It is therefore absorbed by blue and green wavelengths [11]. Venous blood containing less oxygen, absorbs more red light and appears darker. The pigment melanin, which imparts colour to the skin, is strongly absorbed by short wavelengths. Water, the universally present molecule has varying degree of absorption by different wavelengths [11].

Condition for Absorption

Dental structures have different amounts of water content by weight. A ranking from lowest to highest would show enamel (with 2% to 3%), dentin, bone calculus, caries and soft tissue (at about 70%) [11]. Hydroxyapatite is the chief crystalline component of dental hard tissues and has a wide range of absorption depending on the wavelength [11].

In general, shorter wavelengths (500– 1000 nm) are readily absorbed in pigmented tissue and blood elements. Argon is highly attenuated by hemoglobin [11]. Diode and Nd: YAG has a high affinity for melanin and less interaction with hemoglobin. The longer wavelengths are more interactive with water and hydroxyapatite. The largest absorption peak for water is just below 3000 nm which is at Er: YAG wavelength. Erbium is also well absorbed by hydroxyapatite. CO_2 at 10,600 nm is well absorbed by water and has greatest affinity for tooth structure [11].

The second effect is transmission of the laser energy directly through the tissue with no effect on target tissue i.e. inverse of absorption. This effect is highly dependent on wavelength of laser light. Water, for example is relatively transparent to the shorter wave lengths like argon, diode and Nd: YAG, whereas tissue fluids readily absorb the erbium family and CO_2 at the outer surface so that there is little energy transmitted to adjacent tissues [11].

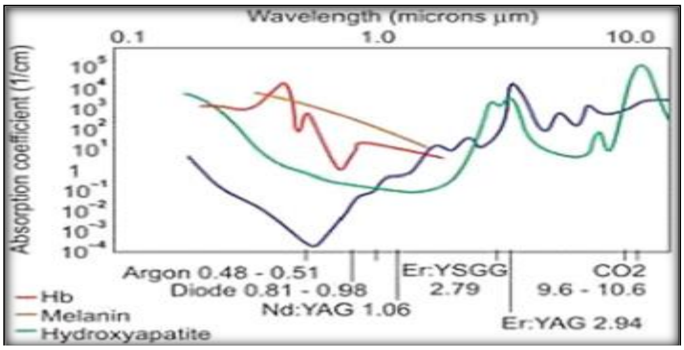


Figure 10 Approximate absorption curves of the prime oral chromophores

The third effect is reflection, which is the beam redirecting itself off the surface having no effect on the target tissue. Caries – detecting laser device uses the reflected light to measure the degree of sound tooth structure. The reflected light could maintain its collimation in a narrow beam or become more diffuse. The laser beam generally becomes more diverge as the distance from the hand piece increases. However, the beam from some lasers can have adequate energy at distances over 3m. This reflection can be dangerous because the energy is directed to an unintentional target such as the eyes [11].

The fourth effect is scattering of laser light, weakening the intended energy and possibly producing no useful biologic effect. Scattering of laser beam could cause heat transfer to the tissues adjacent to the surgical site and unwanted damage could occur [11].

Effects of laser energy on oral tissues

Absorption of laser light by the target produces effects which are beneficial and primary of laser energy. The principal effect of laser energy is Photo thermal (i.e. conversion of light energy into heat). This thermal effect of laser energy on tissue depends on the degree of temperature rise and the corresponding reaction of interstitial and intercellular water. The rate of temperature rise plays an important role in this effect and is dependent on several factors such as cooling of surgical site and the surrounding tissue's ability to dissipate the heat. As the laser energy is absorbed, heating occurs [12].

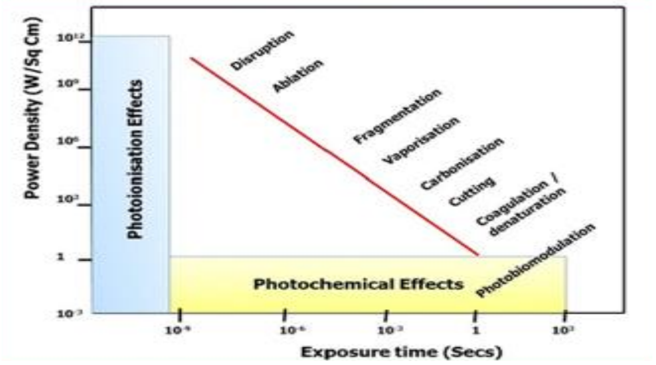


Figure 11 Thermal effect of laser energy on tissue

Hyperthermia occurs when the tissue is elevated above normal temperature but is not destroyed. At temperatures of approximately 60°C, proteins begin to denature without any vaporization of underlying tissue. The tissue whitens or blanches which is useful in surgical cases [11].

Coagulation refers to the irreversible damage to tissue, congealing liquid into a soft semi-solid mass. This produces the desirable effect of hemostasis by contraction of the wall of the vessel [12]. Incision is accomplished by placing the laser at its focal length (i.e. smallest possible spot size) near the tissue or touching the tissue if a contact tip is used. This increases the density of the power and condenses the effect into a small area. This laser target distance varies according to delivery system and ranges from contact with a contact laser to 0.5 mm for a hollow wave-guide to more than 1 cm for an articulated arm laser [13].

Soft tissues edges can be welded together with a uniform heating to 70°C to 80°C where there is adherence of layers because of stickiness to collagen molecules helical unfolding and intertwining with adjacent segments.

When the target tissue containing water is elevated to a temperature of 100°C, vaporization of water occurs, also known as ablation [14]. This allows removal of large areas of very superficial epithelium the laser away from the target, to increase the spot size [15]. Defocusing effectively lowers the density of the laser energy/units and causes the laser to act more superficially over a larger surface area. The target distance may vary dramatically depending on the type of delivery system, the available power and the desired depth of penetration [15].

The apatite crystals and other minerals in dental hard tissue are not ablated at this temperature, but the water component is vaporized and the resulting jet of steam expands and then explodes the surrounding matter into small particles. This mixture of steam and solids is then suctioned away. This micro explosion of apatite crystal is termed ***"Spallation"*** [11]. If the tissue temperature continues to be raised to about 200 degrees Celsius it is dehydrated and then burned in the presence of air, Carbon as the end – product absorbs all wavelengths. Thus, if laser energy continues to be applied, the surface carbonized layers absorb the incident beam, becoming a heat sink and preventing normal tissue ablation [11]. Thus, for dental applications excessive heat must be avoided to protect the pulp.

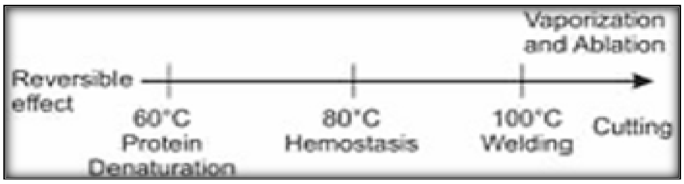


Figure 12 Effect of heat on oral tissues

Photochemical Effects

It causes target cells to start light – induced chemical reactions (e.g.: curing of composite resins) and breaking of chemical bonds (e.g.: using photosensitized drugs exposed to laser light to destroy tumour cells, a process called photodynamic therapy). Initial absorption takes place by specific molecules [15].

Some of the applications of photochemical effects are:

1. Photo activated dye disinfection using lasers
2. Photo polymerization of light cured restorative resin using argon laser.
3. Photochemical bleaching

A laser can be used with powers well below the surgical threshold for biostimulation (low–level laser therapy) producing more rapid wound healing, pain relief, increased collagen growth and a generalized anti– inflammatory effect [11].

For very high rates of energy deposition shock waves can be generated in the tissue by mechanisms such as bubble expansion / plasma formation. It causes dielectric breakdown in tissue caused by shock wave plasma expansion resulting in localized mechanical rupture [15].

The pulse of laser energy into a crystalline structure can produce an audible shock wave, which could explode or pulverize the tissue with mechanical energy. This is an example of photo acoustic effect of laser light [11].

Effects of Laser on Tissues

Tissue interaction is maximized by matching the proper wavelength with adequate amount of power with the chromophore present in the tissue. Effects of laser light on tissues can be grouped into the following:

1. Reflection
2. Scattering/dispersion
3. Absorption
4. Transmission Effects of light energy on target tissues.

- Photo-thermal effects – Coagulation , Vaporization
- Photo-acoustic effect – Disruption and Plasma effect
- Flourescence – Caries detection – Mucosal evaluation – Photo-chemical effects – Stimulate chemical reaction – Breaks and creates chemical bonds
- Photo-biomodulation – Pain relief and Wound healing

CONCLUSION

Laser technology for hard tissue and soft tissue applications is at a high state of refinement, having decades of developments, research and further improvements are yet to occur. Looking into the future it is expected that specific laser technologies will become essential components of regular and contemporary dental practices.

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