Chapter One

Introduction

1.1 Introduction

The characteristics that featured the laser from traditional light is proved to be one of the most useful tool and promising in many fields, whether industrial application (cutting, drilling ,Marking….), Scientific(spectroscopy, Heat treatment, photochemistry , laser scanner, laser cooling , nuclear fusion,,) ,Military(defensive countermeasures, targeting….),and laser in research and medicine field.(Sharma,2010).

Lasers started out in research laboratories, and many of the most sophisticated ones are still being used there. Chemists, biologists, spectroscopists, and other scientists count lasers among the most powerful investigational tools of modern science. In the laboratory the other characteristics of laser light are often important too .Because a laser's beam contains light of such pure color, it can probe the dynamics of a chemical reaction while it happens or it can even stimulate a reaction to happen. In medicine, the laser's narrow beam has proven a powerful tool for therapy (Niemz, 2002).

In particular; the carbon dioxide laser has been widely adopted by surgeons as a bloodless scalpel because the beam cauterizes an incision even as it is made. Indeed, some surgeries that cause profuse bleeding had been impossible to perform before the advent of the laser. The laser is especially useful in ophthalmic surgery because the beam can pass through the pupil of the eye and weld, cut, or cauterize tissue inside the eye. Before lasers, any procedure inside the eye necessitated cutting open the eyeball. Laser used in skin carcinoma or port wine marks should be treated at wavelength for small penetration depth in order to protect the deeper in layers or treatment of subcutaneous cancer must be performed at wavelengths with greater penetration depth. The most spectacular outcomes of laser application in medicine have been achieved in laser surgery, dermatology, and dentistry **(**Niemz, 1996).

Laser used in dentistry it basically remained a field of research. Especially in caries therapy the most frequent dental surgery – conventional mechanical drills are still superior compared to most types of lasers, particularly CW or long-pulse lasers. However, many clinical studies and extensive engineering effort still remain to be done in order to achieve satisfactory results. We should keep in mind that mechanical drills have improved over several decades until the present stage was reached, and that the development of suitable application units for laser radiation also takes time. Also laser is using in teeth bleaching; the desire to have whiter teeth and the bleaching technique has been documented since the mid-nineteenth century, it detailed in this research (Niemz, 2002).

1.2 Research Problem

Teeth stains by different caused, it is cause appearance unwanted, manifestoes numbers of techniques uses to improves the color of teeth, each of there was needing different time differ from other, a laser become wide use in the beauty field, in this research was study the pulp temperature measurement during bleaching process and laser efficiency in teeth bleaching depends on color change, by using different wavelengths with different powers and different times.

1.3 Aims of This Work

The aims of this research are to:

-Study of laser hard tissue interaction.

-The pulp temperature measurement.

-Evaluated different lasers efficiencies biased on the tooth color change.

1.4 Literature Review

Bleaching techniques achieved significant advances with the use of coherent or incoherent radiation sources to activate the bleaching agents. Nicklaus. U.Wetter, Marcia C.S. Barroso, DDS and Jose´ studied dental bleaching efficacy with diode laser and light emitting diode(LED) irradiation, an in vitro Study in school of dentistry, university of Sao Paulo, where they used a total of 60 bovine incisors were randomly divided into six groups, three for each bleaching agent, receiving only agent, agent and LED (wavelength 470 nm), agent and 1.6W, diode laser 808 nm .where the result was Significant differences in the chromatic value are obtained for the two whitening agents and for the different light sources. In terms of lightness, the association of laser and whiteness hydrogen peroxide (HP) bleaching gel showed significantly better results than when the same agent was used alone,(Nicklaus, *et al.*,2004,).

Also N.Gutknecht*et al.*, they are studied laser-assisted whitening method, by using Er:YAG mode 1: 0.79W, 10Hz, pulse duration 700 μsec, 5 mm spot size; 10-second illumination periods with a 30-second waiting time between periods.

Er: YAG mode 2: 0.59W, 10Hz, pulse duration 700 μsec, 5 mm spot size; t 20-second illumination periods with 10-second waiting times between periods.

Er: YAG mode 3: 0.59W, 10Hz, pulse duration700 μsec, 5 mm spot size; 60second illumination period. Total energy delivered: 35.4 J. Nd: YAG: 5.6 W, 60Hz, 5 mm spot size; three 10-second illumination periods with 15-second waits times between the periods.

Diode laser (808 nm): 4.9W, 5 mm spot size; three 10-second illumination periods with 15-second waiting times between the periodsof the gel. The tooth white method makes use of the fact that the Er: YAG laser wavelength has a water absorption peak in the vicinity of 3 μm. Since water is the major component of the aqueous bleaching gels, this eliminates the need for any additional absorbing particles in the bleaching gels. More importantly, taking into account thermal burden considerations, the tooth white procedure represents the most effective and least invasive laser-assisted tooth whitening method possible. Due to its high absorption in bleaching gels, the Er: YAG laser beam is fully absorbed in the gel and does not penetrate to the hard tissue or the pulp. All of the laser energy is thus effectively used for the heating of the gel. There is no direct heating of the dental tissue and the pulp, as in the case with other laser-assisted whitening methods. As consequence, the procedure can be performed with a minimal undesirable thermal burden on the tooth, and the tooth whitening speed can be safely increased by 5 – 10 times(Gutknecht *et al.*,2011).

R. Jozef (et al…), are studies the evaluate the influence of the temperature rise during laser bleaching on the pulp, the postoperative sensitivity, and eventual enamel alterations. The efficiency is evaluated on the basis of the color change in vitro and in vivo. These studies led to temperature rise in the pulp. a CO_2 laser (10,600 nm) on teeth for bleaching *him use of* purposes led to a temperature increase of 13.1 to 22.3^{o}C with gel at the enamel surface and 6.9 to 16.6^{o}C at the pulp side of the dentine. At present this wavelength is no longer used for dental bleaching. Laser activation with a 830 nm *diode laser* (30 s, 3 W) without bleaching gel may result in a temperature increase of 16 ^{o}C in the pulp chamber; when applying the gel during laser activation only 8.7^{o}C temperature increase was recorded. With a 915 nm *diode laser*, there was an increase of temperature with 26.7 ^{o}C at 3W-20s and 12.2^{o}C at 1.5W-20 s. In the same study temperature rise was lower after application of a bleaching gel; the decrease was product related: By White gel (by Dental, Pistoia, Italy) at 3Wresultedin a rise of 17.0□C and at 1.5W of 7.6^{o}C with Whiteness HP (FGM Produtos Odontol´ogicos, Joinville, Brazil) it was+25.6^{o}C at 3W and +6.0□C at 1.5W.The bleaching gel thus acts as a selective absorber near the dental surface, preventing light penetration into the internal tooth structure an increase of 2.61^{o}C with a *diode laser* 810 nm ,4W,20 s,(Jozef et al.., 2015).

Sulieman et al., in 2006 are used diode 820nm with power (3, 2, 1) W, for the same exposure time 30s, the result in this case for the temperature in the pulp was (11.6, 7.7, 5.23)^{o}c respectively that without gel, when used gel the result was (8.7, 6.8, 5.5) ^{o}c respectively (Jozef et al.., 2015).

1.5 Research Methodology

To achieve the objectives of this dissertation; the data about the teeth bleaching in general and by use laser light will be collected, the teeth that will be paint by hydrogen peroxide gel (35%) before irradiation. The sample will expose to various wavelength with different power and the same time application, and then the temperature measurement during the bleaching without gel and with gel, and observing the teeth color change.

1.6 Dissertation Layout

This work consists of four chapters, chapter one consist Introduction ,Research Problem, Aim of this work ,literature review, research methodology and this layouts, chapter two consist basic concepts of laser, what is the tooth and laser tissue interaction, chapter three consist experimental part (the materials and devices and method),chapter four consist results and discussion, conclusion, recommendation , lastly Reference and Appendix of tables.

Chapter Two

Basic Concepts

2.1 Laser

The word laser is an acronym for light Amplification by Stimulated Emission of Radiation. Radiation means the electromagnetic radiation. The light and other forms of electromagnetic radiations bear dual nature and behave as waves and particles (called photons). Stimulated emission means a special way of producing extra energy as light stimulating atoms and molecules contrary to the spontaneous emission .Amplification means increase in the amount of light energy in stimulated emission one photon stimulates an atom or molecule to produce one more photon which in turn can stimulate one more photon.(Sharma,2010).

Light means the electromagnetic wave (both visible and infrared and ultraviolet).A laser differs from a conventional light source four major a specs .First the laser emits radiation in highly unidirectional (collimation) beam ,secondly the radiation is extremely pure in color (Monochromaticity),thirdly high degree of coherence, the wavelength spread is very small. These three properties enable the output of a laser to be brought to a very small focus without any limitation imposed by chromatic aberration in the focus lens system. The fourth characteristic of laser radiation is that the intensity can greatly exceed that of conventional source, particularly in the case of pulsed lasers (Sharma, 2010).

2.1.1 Laser Construction

Basically, every laser system essentially has an active/gain medium, placed between a pair of optically parallel and highly reflecting mirrors with one of them partially transmitting, and an energy source to pump active medium. The gain media may be solid, liquid, or gas and have the property to amplify the amplitude of the light wave passing through it by stimulated emission, while pumping may be electrical or optical (Chandra et al.., 2012)

The gain medium used to place between pair of mirrors in such a way that light oscillating between mirrors passes every time through the gain medium andafter attaining considerable amplification emits through the transmitting mirror. Let us consider an active medium of atoms having only two energy levels: excited level E_2 and ground level E_1. If atoms in the ground state, E_1, are excited to the upper state, E_2, by means of any pumping mechanism (optical, electrical discharge, passing current, or electron bombardment), then just after few nanoseconds of their excitation, atoms return to the ground state emitting photons of energy $h\nu = E_2 - E_1$. According to *Einstein's* 1917 theory, emission process may occur intwo different ways, either it may induced by photon or it may occur spontaneously

The former case is termed as *stimulated emission*, while the latter is known as *spontaneous emission*. Photons emitted by stimulated emission have the same frequency, phase, and state of polarization as the stimulating photon; therefore they add to the wave of stimulating photon on a constructive basis, thereby increasing its amplitude to make lasing. At thermal equilibrium, the probability of stimulated emission is much lower than that of spontaneous emission , therefore most of the conventional light sources are incoherent, and only lasing is possible in the conditions other than the thermal equilibrium*(*Chandra et al.*,2012)*

2.1.2Essential Elements of a Laser

The laser device is consists of three essential elements: an external energy source or pump, again medium, and an optical cavity or resonator. These three elements are shown schematically in figure (2.1); laser systems with moderate or high power outputs also typically require a cooling system (Frank, 1996).

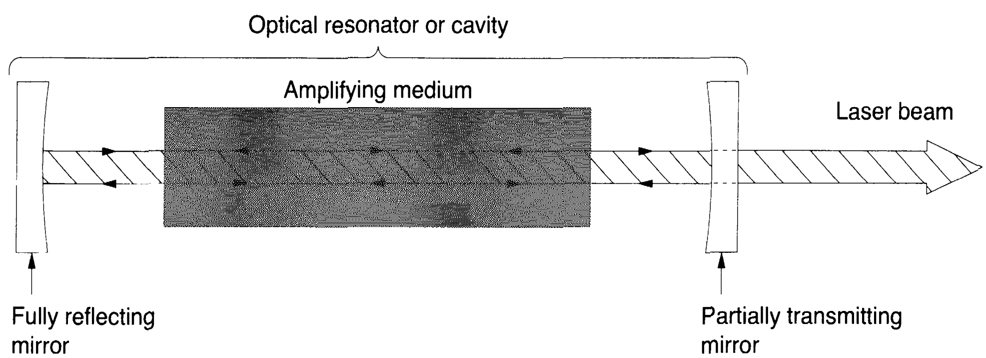


Fig 2.1: Essential Elements of a Laser

A) Pumping

The pump is an external energy source that produces a population inversion the laser gain medium. The pump can be optical, electrical, chemical, or thermal in nature. For gas lasers such as He-Ne laser, the most commonly used pump mechanism is an electrical discharge. The important parameters governing this type of pumping are the electron excitation cross sections and lifetimes of the various energy level .The first laser developed by T.Maiman at the Hughes research laboratories in 1960, was a pulsed ruby laser which operated at the visible red wavelength of 694.3nm.fig 2.2 shows drawing of the ruby laser device. To excite the Cr+3 impurity ions in the ruby rod, Maiman used a helical flash lamp filled with xenon gas. This particular method of exciting the laser medium is known as optical pumping , solid and liquid gain media are typically optically pumped either by a flash lamp or another laser (Frank, 1996).

Fig 2.2 Ruby Laser Device

B) Gain Medium

Laser systems are typically named by the makeup of the gain medium used in the device, the participating energy levels in the gain medium which may be a gas, liquid or solid determine the wavelength of the laser radiation .because of the large selection of laser media, the range of available laser wavelength extends from the ultraviolet well into the infrared region .In some lasers, the amplifying medium consists of two the laser host medium and the laser atoms. For example, the Nd: YAG laser is crystal of yttrium aluminum garnet (commonly called YAG), whereas the laser atoms are the trivalent neodymium ions. The most important requirement of the amplifying medium is its ability support population inversion between two energy levels of the laser atoms .This accomplished by exciting (or pumping) more atoms into higher energy level than exist in the lower level(Frank, 1996).

C) Resonator

The third basic element is a resonator , is an optical “feedback device” that directs photons back and forth through the laser amplifying medium .The resonator or optical cavity, it is most basic form consists of a pair of carefully aligned plane or curved mirrors centered along the optical axis of laser systems. One of the mirrors is chosen with a reflectivity as close to 100% as possible. The other is selected with reflectivity somewhat less than 100% to allow part of the internally reflecting beam to escape and become the useful laser output beam (Frank, 1996).

C) Cooling System

Overall efficiency is an important operating characteristic of laser system. The overall efficiency of a laser system is the ratio of the total power required to pump the laser(sometime called the wall plug), power to the optical output power of the laser. Laser systems with solid gain media are typically cooled by surrounding the gain medium (and sometime the optical pump) in a cooling jacket water, or cooling oil, flows through the jacket, removing heat from the laser system. Laser systems with gas or liquid gain media can be cooled by this same mechanism, or byflowing the lasing medium itself through the cavity and cooling it before returning it to the cavity where it is again pumped. Lasers with lower heat losses can sometimes be sufficiently cooled by forced air. Low power lasers such as the He-Ne laser often need no external cooling system. In a high power laser, the cooling system is an essential part of the system (Frank, 1996).

2.1.3General Properties Laser

A) Monochromaticity

Monochromaticity is the ability of laser to produce a well defined color or wavelength (Sharma, 2006).

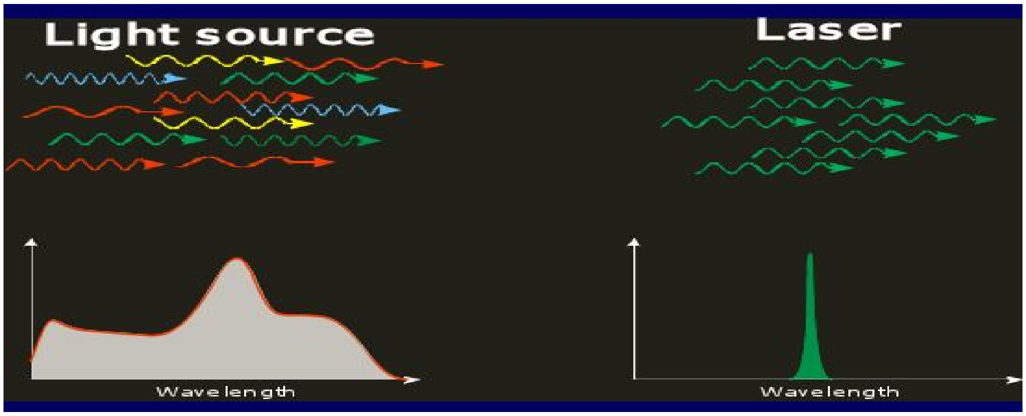


Fig 2.3 Explain the Laser Monochromaticity

B) Coherence

It refers to the degree of correlation between the phase at two different points or beam of light. These property stats that all photons emitted from the laser are exactly in the same phase. As waves they (crest) and (valley) at the same time and hence all are lined up with each other .In lasers, it arises from the stimulated emission process, which provides the amplification. The concept of coherence is one of considerable interest in wide variety of laser applications such as holography, Doppler velocimetry and interferometric measurements techniques useful in quality control (Sharma, 2010).

Coherence can be divided in to two parts:-

1. Temporal Coherence

Temporal coherence refers to correlation in phase at given point in the space over length of time or it can be defined as the measure of the correlation between phases of light wave at different points along the direction of propagation. As it is measured along the direction of propagation this is also known as longitudinal coherence.

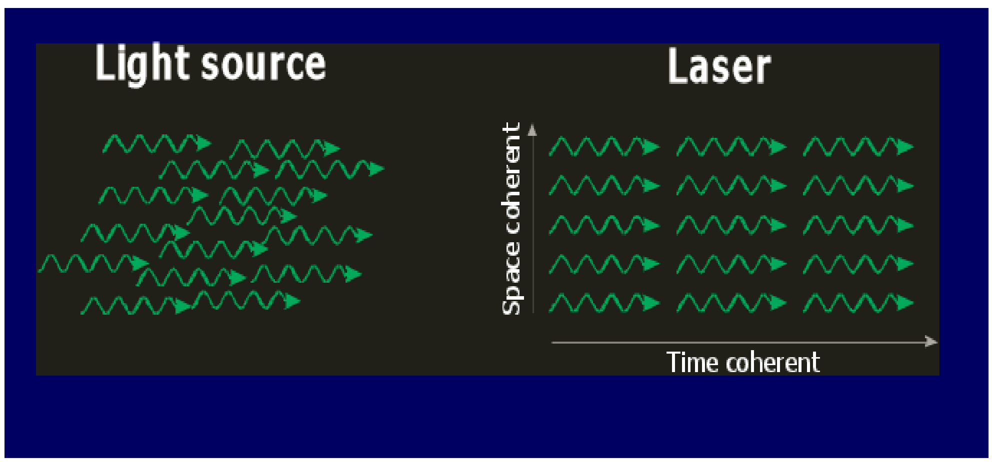


Fig 2.4 The different between Conventional Light Source and Laser Time Coherent

2. Spatial Coherence

Spatial coherence is also referred as transverse or lateral coherence and is measure of the correlation between the phase of a light wave at different point transverse to the direction of propagation .Spatial coherence tells us how uniform the phase of the wave front is. Spatial coherence result in the effect of directionality .A good spatial coherence means a good directionality (Sharma, 2006).

C) Divergence and Directionality

Directionality is property of laser light which allows it to stay tight bound confined beam for a large distance. One of the most striking Properties of laser is its directionality, that is, its output is in the form of an almost parallel beam. Owing to its directional nature it can carry energy and data to very long distances for remote diagnosis and communication purposes. In contrast, conventional light sources emit radiation isotropic ally, therefore, very small amount of energy can be collected using lens. Beam of an ideal laser is perfectly parallel, and its diameter at the exit window should be same to that after traveling very long distances although in reality, it is impossible to achieve (Sharma, 2006).

2.1.4 Laser Types

The various types of laser that have been developed so far, display a very wide range of physical and operating parameters. Indeed, if lasers are characterized according to the physical state of the active material, one uses the description of solid state, liquid or gas lasers. A rather special case is where the active material consists of free electrons, at relativistic velocities, passing through a spatially periodic magnetic Field (free-electron lasers). If lasers are characterized by the wavelength of the emitted radiation, one refers to infrared lasers, visible lasers, and UV and X-ray lasers. The corresponding wavelength may range from _ 1mm (i.e. millimeter waves) down to _ 1 nm (i.e. to the upper limit of hard X-rays). The span in wavelength can thus be a factor of _ 106 (we recall that the visible range spans less than factor 2, roughly from 700 to 400 nm). Output powers cover an even larger range of values. For CW lasers, typical powers go from a few mw, in lasers used for signal sources (e.g. for optical communications or for bar-code scanners), to tens of kW in lasers used for material working, to a few mW(5mWso far) in lasers required for some military applications (e.g. for directed energy weapons). For pulsed lasers the peak power can be much higher than for CW lasers. The physical dimensions can also vary widely. In terms of cavity length, for instance, the length can be as small as _ 1 μm for the shortest lasers up to some km for the longest (e.g. a laser 6.5 km long, which was set up in a cave for geodetic studies).

This wide range of physical or operating parameters represents both strength and weakness. As far as applications are concerned, this wide range of parameters offers enormous potential in several fields of fundamental and applied sciences. On the other hand, in terms of markets, a very wide spread of different devices and systems can be an obstacle to mass production and its associated price reduction *(*Chandr et al.*, 2012)*

2.2Tooth

2.2.1The Human Tooth

The human tooth consists of mainly three distinct segments called enamel, dentin and pulp. A schematic cross-section of a human tooth is shown in fig (2.5) (Niemz, 2002).

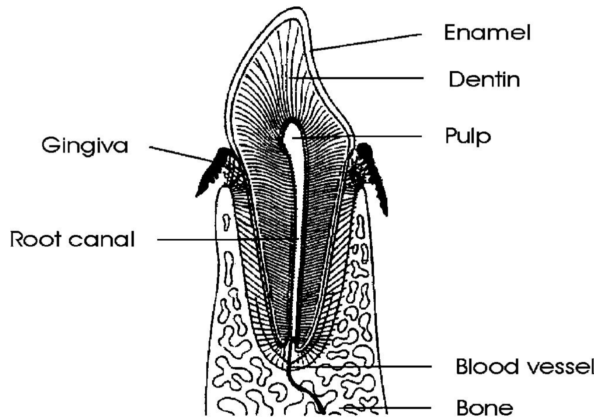


Fig 2.5 Cross-Section of a Human Tooth

(A) Enamel

The enamel is the hardest substance of the human body. It is made of approximately 95% (by weight) hydroxyl apatite, 4% water, and 1% organic matter. Hydroxyapatite is a mineralized compound with the chemical formulaCa_{10} $(PO4)_6(OH)_2$. Its substructure consists of tiny crystallites which form so called enamel prisms with diameters ranging from 4 µm to 6µm. The crystal Lattice itself is intruded by several impurities, especially Cl^-, F^-, Na^+, K^+, and Mg^{+2}.(Niemz,2002).

(B) Dentin

The dentin, on the other hand, is much softer. Only 70% of its volume consists of hydroxyl apatite, whereas 20% is organic matter – mainly collagen fibers – and 10% is water. The internal structure of dentin is characterized by small tubuli which measure up to a few millimeters in length, and between100nm and 3 µm in diameter. These tubuli are essential for the growth of the tooth (Niemz , 2002).

(C) Pulp

The pulp, finally, is not mineralized at all. It contains the supplying blood Vessels, nerve fibers, and different types of cells, particularly odontoblasts and fibroblasts. The pulp is connected to peripheral blood vessels by a small channel called the root canal.

The tooth itself is embedded into soft tissue called the gingival which keeps the tooth in place and prevents bacteria from attacking the root (Niemz,1996).

2.2.2 Use of Lasers in Dentistry

The application of this light energy results in the modification or removal of tissue.

In root canal treatment, lasers may be used to remove the dental pulp and organic debris, and to modify the dentinal walls by inducing melting and resolidification cycles resulting in the enlargement the walls of the root canal system. Once the preparation is completed, the root canal is obturated, and the laser may be used to soften and mold the obdurate material to the prepared root canal system. These procedures are accomplished by the interactions between the laser light, dentin and obturating materials. The net result of laser tissue interaction will depend upon the degree of laser energy that is absorbed or scattered by the tissue or the tissue fluid. Different parameters such as laser wavelength, energy level and mode of application and tissue characteristics will influence the effect of a particular laser on the tissue.The interaction of laser in root dentin is primarily a thermal effect (increased temperature). Another mode of laser effect in endodontic is a chemical effect (photochemical).Other used of laser in teeth bleaching (Niemz, 2002).

2.2.3 Mechanism of tooth bleaching

Bleaching is a decolourisation or whitening process that can occur in solution or on a surface. The color producing materials in solution or on a surface are typically organic compounds that possess extended conjugated chains of alternating single or double bonds and often include heteroatom's, carbonyl, and phenyl rings in the conjugated system and are often referred to as a chromophore. Bleaching and decolourisation of the chromophore can occur by destroying one or more of the double bonds in the conjugated chain, by cleaving the conjugated chain, or by oxidation of other chemical moieties in the conjugated chain.Hydrogen peroxide oxidises a wide variety of organic and inorganic compounds (Joiner, 2006).

2.3 Light Interaction with Matter

Matter can act on electromagnetic radiation in manifold ways. In Fig (2.6)a typical situation is shown, where a light beam is incident on a slice of matter. In principle, three effects exist which may interfere with its undisturbed Propagation:-

– Reflection and refraction,

– Absorption,

– scattering.

Reflection and refraction are strongly related to each other by Fresnel’s laws. Therefore, these two effects will be addressed in the same section. In Fig (2.6)

Refraction is accounted for by a displacement of the transmitted beam. In medical laser applications, however, refraction plays a significant role only when irradiating transparent media like corneal tissue. In opaque media, usually, the effect of refraction is difficult to measure due to absorption and scattering.

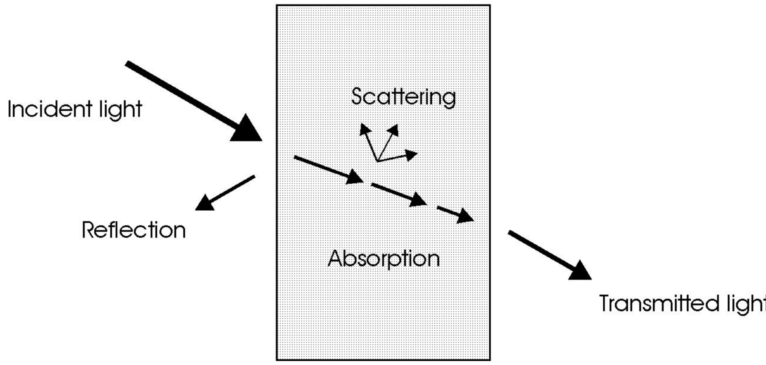


Fig 2.6 Geometry of reflection, refraction, absorption, and scattering

Only nonelected and no absorbed or forward scattered photons are transmitted by the slice and contribute to the intensity detected behind the slice. The ratio of transmitted and incident intensities is called transmittance. Which of the losses –reflection, absorption, or scattering – is dominant primarily depends on the type of material and the incident wavelength in laser surgery, knowledge of absorbing and scattering properties of a selected tissue is essential for the purpose of predicting successful treatment. The index of refraction might be of considerable interest when applying laser radiation to highly reflecting surfaces such as metallic implants in dentistry or orthopedics. (Niemz , 2002).

2.3.1 Reflection and Refraction

Reflection is defined as the returning of electromagnetic radiation by surfaces upon which it is incident. In general, a reflecting surface is the physical boundary between two materials of different indices of refraction such as air and tissue. The simple law of reflection requires the wave normal's of the incident and reflected beams and the normal of the reflecting surface to lie within one plane, called the plane of incidence. It also states that the reflection angle θ̀equals the angle of incidence θ as shown in Fig (2.7) and expressed by

$$\theta = \grave{\theta} \quad (2.1)$$

The angles θ and θ̀are measured between the surface normal and the incident and reflected beams, respectively. The surface itself is assumed to be smooth, with surface irregularities being small compared to the wavelength of radiation. This results in so-called specular reflection. In contrast, i.e. when the roughness of the reflecting surface is comparable or even larger than the wavelength of radiation, diffuse reflection occurs. Then, several beams are reflected which do not necessarily lie within the plane of incidence, and no longer applies. Diffuse reflection is a common phenomenon of all tissues, since none of them is provided with highly polished surfaces such as optical mirrors (Niemz , 2002).

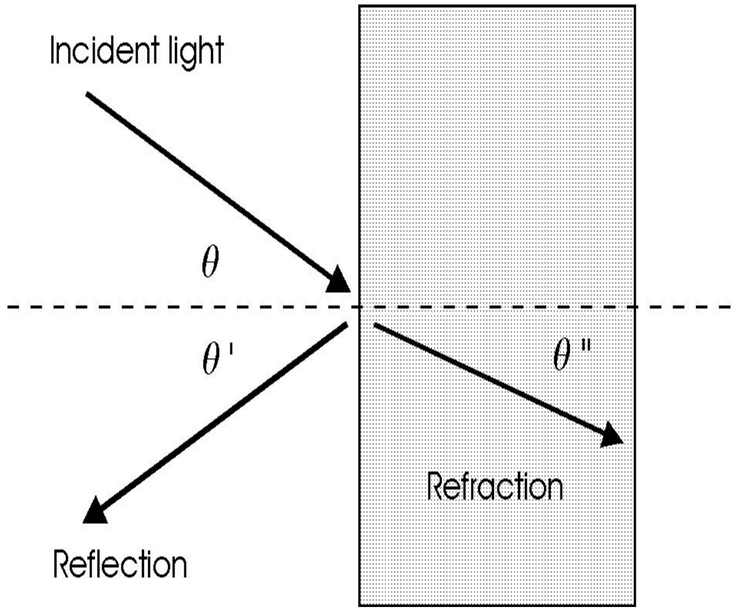


Fig 2.7Geometry of specular reflection and refraction

2.3.2 Scattering

When elastically bound charged particles are exposed to electromagnetic waves, the particles are set into motion by the electric field. If the frequency of the wave equals the natural frequency of free vibrations of a particle, resonance occurs being accompanied by a considerable amount of absorption. Scattering, on the other hand, takes place at frequencies not corresponding to those natural frequencies of particles. The resulting oscillation is determined by forced vibration. In general, this vibration will have the same frequency and direction as that of the electric force in the incident wave. Its amplitude, however, is much smaller than in the case of resonance. Also, the phase of the forced vibration differs from the incident wave, causing photons to slow down when penetrating into a denser medium. Hence, scattering can be regarded as the basic origin of dispersion. Elastic and inelastic Scattering are distinguished, depending on whether part of the incident photon energy is converted during the process of scattering (Niemz , 2002).

2.3.3 Absorption

During absorption, the intensity of an incident electromagnetic wave is attenuated in passing through a medium. The absorbance of a medium is defined as the ratio of absorbed and incident intensities. Absorption is due to a partial conversion of light energy into heat motion or certain vibrations of molecules of the absorbing material. A perfectly transparent medium permits the passage of light without any absorption, i.e. the total radiant energy entering into and emerging from such a medium is the same. Among biological tissues, cornea and lens can be considered as being highly transparent for visible light. In contrast, media in which incident radiation is reduced practically to zero are called opaque. The terms “transparent” and “opaque” are relative, since they certainly are wavelength-dependent. Cornea and lens, for instance, mainly consist of water which shows a strong absorption at wavelengths in the infrared spectrum. Hence, these tissues appear opaque in this spectral region. Actually, no medium is known to be either transparent or opaque to all wavelengths of the electromagnetic spectrum. A substance is said to show general absorption if it reduces the intensity of all wavelengths in the considered spectrum by a similar fraction. In the case of visible light, such substances will thus appear grey to our eye. Selective absorption, on the other hand, is the absorption of certain wavelengths in preference to others. The existence of colors actually originates from selective absorption. Usually, body colors and surface colors are distinguished (Niemz , 2002).

Body color is generated by light which penetrates a certain distance into the substance. By backscattering, it is then deviated and escapes backwards from the surface but only after being partially absorbed at selected wavelengths. In contrast; surface color originates from reflection at the surface itself.).The ability of a medium to absorb electromagnetic radiation depends on a number of factors, mainly the electronic constitution of its atoms and molecules, the wavelength of radiation, the thickness of the absorbing layer, and internal parameters such as the temperature or concentration of absorbing agents. Two laws are frequently applied which describe the effect of either thickness or concentration on absorption, respectively. They are commonly called Lambert's law and Beer's law, and are expressed by:

$$I(Z)=I_O exp(-\alpha z) \qquad (2.2)$$

And

$$I=I_O \exp(-kcz) \qquad (2.3)$$

Where z denotes the optical axis $I(Z)$ is the intensity of distance z ,I_O is the incident intensity α is the absorption coefficient of the medium , c is the concentration of absorbing agents ,and k depends on internal parameters other than concentration. Since both laws describe the same behavior of absorption, they are also known as the Lambert–Beer law. From (2.2), we obtain

$$Z = \frac{1}{\alpha} \ln I/I_O \qquad (2.4)$$

The inverse of the absorption coefficient α is also referred to as the absorption length

$$L.L = \frac{1}{\alpha} \qquad (2.5)$$

The absorption length measures the distance z in which the intensity $I(z)$has dropped to 1/e of its incident value Io .

Chapter Three

Materials and Method

3.1 Introduction

Different types of equipments and methods were used to improve teeth color. Most stains are caused by age, tobacco, coffee, or tea. Other types of stains can be caused by antibiotics, such as tetracycline; or too much fluoride. Ask your oral health care professional about tooth-whitening options. They include a number of over-the-counter whitening systems, whitening tooth pastes, and laser tooth whitening. For maximum whitening, experts agree that peroxide is usually the way to go.

3.2Materials

3.2.1 Teeth Samples

Teeth samples were collected from Khartoum hospital for dental. The teeth were kept formalin in saline solution.

Fig 3.1Teeth Samples

3.2.2 The 35% Hydrogen peroxide gel

-White gel and transmuted

-Chemical component H_2O_2.

- Beyond company.

Fig3.2hydrogenperoxide gel

3.2.3 Containers

Use plastic containers for separating samples.

Fig 3.3Containers for separating samples

3.2.4 Tooth Shades

It paper shades, and explain the degree of stain before and after tooth bleaching.

Fig 3.4 Tooth Shades.

3.2.5 Nd: YAG laser, 1064nm, power 10 W

Nd: YAG lasers are optically pumped using a flashtube or laser diodes. These are one of the most common types of laser, and are used for many different applications.

Nd: YAG laser Figure 3.5 typically emit light with a wavelength of 1064 nm, and maximum output power 100 Watt, adjusted 1 Watt in step, the Nd: YAG laser mode lDORNIER med Tech Medilas 5100 fiber tom Glass I.

Fig 3.5 Nd: YAG laser 1064 nm

3.2.6 Diode laser (915 nm), power 100 mW

Invisible laser radiation, class 3b laser diode gases, peak power 1W, and the average power 100 mW.

Fig 3.6 Diode laser 915 nm

3.2.7 Diode laser (820nm), power 28 mW

Invisible laser radiation, class 3B laser production

Fig 3.7 Diode laser 820 nm in prop.

3.2.8 Diode laser 532nm, power 1000 mW

-Max output power 1000mW.

- Wavelength 532nm, class III laser product.

-Japan-BL-303.

Fig 3.8 Diode laser 532 nm.

3.2.9 Thermocouple

Fig 3.9 Thermocouple

3.3 Methods

Firstly teeth samples were collected from Khartoum hospital for the dental, after that some commonly used lasers were selected in teeth bleaching. The samples were washed by water and dried, then divided into four groups , each group contains four teeth, the methods was applied in two steps to measure the temperature of the pulp during the bleaching process.

The first division without gel after placing goggles on the eye, the first group was irradiated at 90^o angel to the teeth by diode laser(915 nm),with power 100 mW, at different time; first teeth for 30 seconds, secondly the teeth for 40 seconds, thirdly the teeth for 50 second, fourth teeth for 60 seconds. The same process in the other groups where used was repeated, with the second group diode laser(820 nm), with power28mW,with the third group diode laser(532nm),with power 100mW and with the fourth group Nd: YAG laser(1064 nm),with power 10 W. During the bleaching process the temperature was measured by thermocouple, which was introduced into the pulp chamber for each tooth.

In the second division teeth were washed by water and quitted for 15 minutes. The teeth are paint by hydrogen peroxide gel (35%) before irradiation. Then the first group was irradiated at 90^o angle to the teeth by diode laser(915 nm),with power 100 mW,at different time(first teeth for 30 seconds, second teeth for 40 seconds, third teeth for 50 second, fourth teeth for 60 seconds) after that leave the teeth for 10minutes used suction to remove the whitening gel .and repeated the same process in the other groups where used ,with the second group diode laser(820nm), with power28 mW, with the third group diode laser(532nm)with power 100 mW and with the fourth group Nd: YAG laser(1064 nm),with power 10000mW.During the bleaching process the temperature was measured by thermocouple, which was introduced into the pulp chamber for each tooth. The tooth shades were used to observe the change in the color of the teeth.

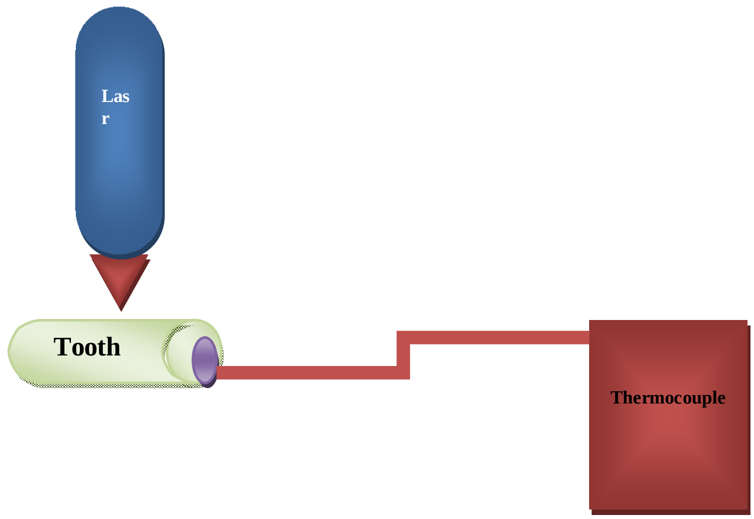


Fig 3.10 the setup of experiment

Chapter Four

Results and Discussion

4.1 Introduction

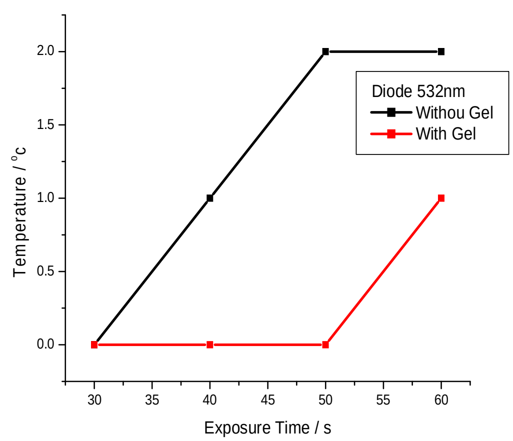
All results of the bleaching without gel and with gel was putted on tables and represented it in curves in this chapter with its discussion, conclusions and recommendation.

4.2 Results and Discussion

4.2.1 Temperature Measurements

Bellow shows the temperature measurements during the bleaching process without gel and with gel for each wavelength.

A) Diode 532nm

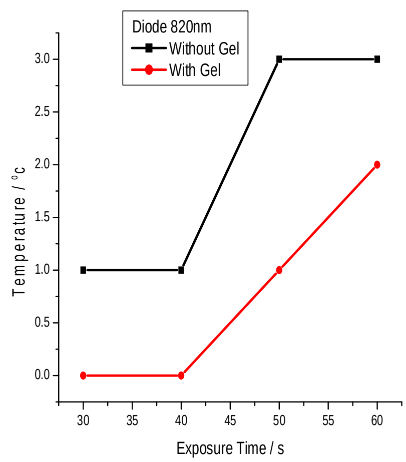


Time/s	Degree of stain(without gel)	Degree of stain (with gel)
30	-	-
40	-	-
50	-	1
60	1	2

Fig4.1changing in temperature during bleaching with power 100mW

Table 4.1and fig4.2, show that when the diode laser 532 nm used with power 100mW, the temperature increased from1^oC up to 2^oC, with increasing exposure times from 40 to 60 second, when bleaching without gel, but when bleaching done with gel the change in temperature was from zero to 1^oc at 60 second, and the degree of stain is 0-2 shades.

B) Diode 820nm



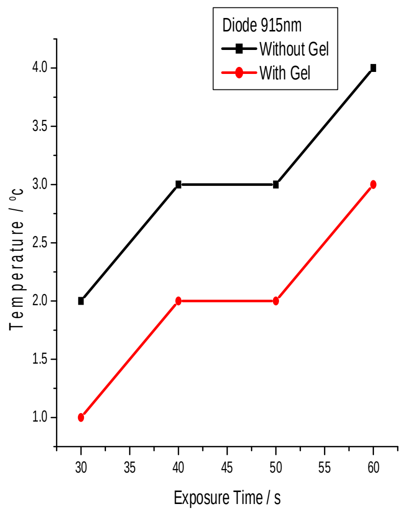
Time/s	Degree of stain(without gel)	Degree of stain (with gel)
30	-	-
40	-	2
50	-	3
60	1	4

Fig 4.2 changing in temperature during the bleaching with power 28mw

When using diode laser 820nm, with power 28mw, according to the table4.2and fig4.3 the temperature increase from1^oC to3^oC with increase exposure times 30-60second, but when the bleaching with gel was done, the change in temperature was zero at 30 and 40 second, and range from $1^oc\ to\ 2^o$c at 50, 60 second respectively, and the degree of stain about0-5 shades.

C) Diode 915nm

When using diode laser 915 nm, with power 100 mW; according to the table 4.3and fig 4.4 the temperature increases from (2C to 4^oC)with increase in exposure times from 30 to 60 second respectively, without the bleaching gel, but when the bleaching done with gel, the change in temperature decreased to 1^oc, and the degree of stain range from 0 to 4.

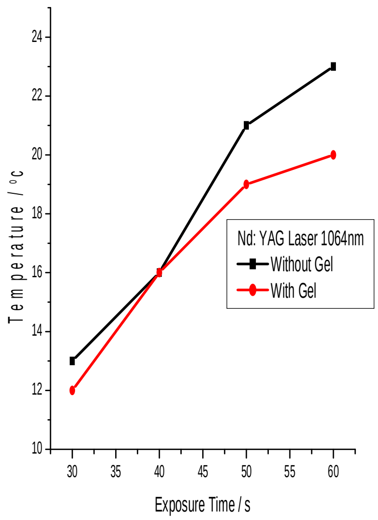


Time/s	Degree of stain(without gel)	Degree of stain (with gel)
30	-	2
40	-	3
50	-	5
60	-	5

Fig 4.3changing in temperature during bleaching, with power 100mW

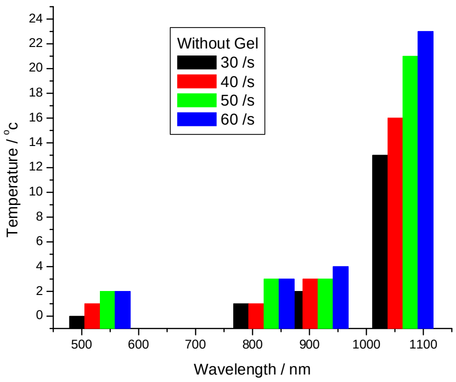
D) Nd: YAG 1064 nm

When using Nd:YAG1064 nm,with power 10 W,according to the table4.4and fig 4.5the temperature was increases (13,16,21,23) ^{o}c,at times (30,40,50,60) second respectively, that without gel, but when the bleaching done with gel, the change in temperature decreased to (12,16,19,20) ^{o}c,at times (30,40,50,60) second respectively. the change of stain it is negative result because the teeth was damaged.



Time/s	Degree of stain(without gel)	Degree of stain (with gel)
30	Damage	Damage
40	Damage	Damage
50	Damage	Damage
60	Damage	Damage

Fig 4.4change in temperature during the bleaching process, with power 10W



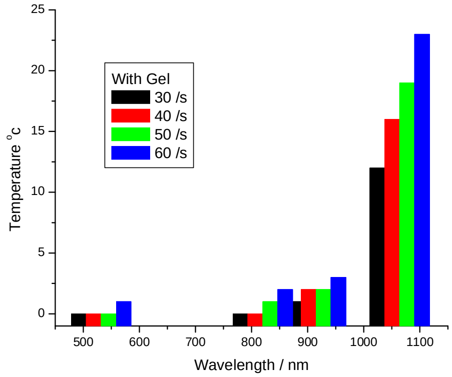


Fig 4.5 changing of temperature related to the wavelength (a) Without gel, (b) With gel.

4.3 Conclusions

The problem of this work is laser teeth bleaching and its effect on the temperature of the pulp, it was found that laser teeth bleaching lead to increasing of the temperature of pulp during the bleaching process; it was proportion to increasing in wavelength, with or without gel. Elevation of temperature was observed when bleaching gel was used by 1^oc in all wavelengths used except for Nd:YAG 1064 nm ,where increase in temperature was from 13^oc to 23^o c that without gel, but when the gel was used the changing in temperature was from12^oc to 20^oc,and in the case of diode 532nm the temperature remained as it's until 50seconds compared with the bleaching without gel.

The best bleaching was achieved when using diode laser with wavelength 820 nm for 60 minutes with degree of stain 4. Whereas Nd: YAG laser with its high power bleaching givs negative result because the teeth was damaged.

4.4 Recommendation

There is some recommendation when using laser teeth bleaching.

-Use the laser diode 820nm to get abutter bleaching result at lower temperatures comparing with the wavelengths used in this research.

-Based on the obtained result don't use high power in the bleaching process because the tooth will damage.

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Appendix:

The tables below show the results

Table 4.1Temperature results when use the Diode 532nm,with power 1w

Wavelength	Power	T/s	(t/^{o}c) With out Gel	(t/^{o}c) With Gel	The degree of stain without gel	The degree of stain with gel
Diode 532nm	1 W	30	0	0	-	-
		40	1	0	-	-
		50	2	0	-	1
		60	2	1	1	2

Table4.2 the results when use the diode laser 820nm,whith power 28 mw

Wavelength	**Power**	**T/s**	**(t/°c) without gel**	**(t/°c) with gel**	**The degree of stain without gel**	**The degree of stain with gel**
820nm	28mW	**30**	**1**	0	-	-
		40	**1**	0	-	2
		50	**3**	1	-	3
		60	**3**	2	1	4

Table 4.3 the results when use the Diode (915nm), with power 100mw

wavelength	Power	T/s	(t/°c) without gel	(t/°c) with gel	The degree of stain without gel	The degree of stain with gel
915nm	100mW	30	2	1	-	2
		40	3	2	-	3
		50	3	2	-	5
		60	4	3	-	5

Table 4.4 the resultes when use the Nd:YAG 1064nm,with power 10W.

Wavelength	Power	T/s	(t/°c) without gel	(t/°c)with gel	The degree of stain without gel	degree of stain with gel
1064nm	10 W	30	13	12	Damage	Damage
		40	16	16	Damage	Damage
		50	21	19	Damage	Damage
		60	23	20	Damage	Damage