Sudan University of Science and Technology

Collage of Graduate Studies

Clinical Evaluation of Laser Application Versus conventional Surgery in Operculectomy

التقييم السريري لاستخدام الليزر في ازلة اللثة الزائدة حول السن المطمور جزئياً مقارنة بالجراحة التقليدية

A Graduation Research Submitted for the partial fulfillment of the Requirement for the Higher Diploma of Laser Application in Medicine (Dentistry)

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Dedication

To my father, mother, my sisters
and
my brother,
with my constant love.

Muddathir

Acknowledgement

Special acknowledgement is due to Dr. **Bakri Gobara Gismalla**, my supervisor, whose continuous encouragement has brought me far and whose powerful intellects have humbled me and showed me how much further I have to go. His support and valuable advice have made this work possible. There is no way to express the depth of my feeling and respects towards him.

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My great thanks are extended to my wife Eyman and to my wonderful child Mohammed for their constant love and joy in my life.

Muddathir

Abstract:

The aim of this study is to evauate the efficiency of the use of lasers in clinical techniques used in operculectomy, with particular reference to the diode laser (980nm), and to compare it with the conventional periodontal surgical technique.Ten patients. with bilateral pericoronal inflammation were treated by phase one therapy then the operculum around one tooth was removed by diode laser 980 nm with 1.5- 2 Watts power in continuous wave mode, and the contra lateral operculum was removed after two weeks from the laser operculectomy by conventional surgery.The surgical phase ie. Gingivectomy was done using size 15c scalpel with distal molar flap technique

All the patients experienced a sensation of pain during the laser surgery which subsides during and immediately after the laser operculectomy. And then started again at the second day of the treatment then it subsided during period of two weeks. All the patients experienced a sever post operative pain immediately after the conventional operculectomy. Which started to be subsided during period of two weeks. A statistically significant result shows less pain in laser operculectomy procedures. (p value = 000). No swelling was claimed to be associated with laser operculectomy during the period of follow up while Conventional operculectomy shows mild swelling one day post operatively which started to be subsided. The evaluation of mean swelling size during the period of two weeks following laser operculectomy comparing it with conventional operculectomy shows a statistically significant result with less swelling in laser operculectomy than conventional procedure (p value = 000). Gingival index for laser operculectomy shows provoked bleeding during and immediately after laser surgery it disappears the day after the treatment. Gingival index following conventional operculectomy shows spontaneous bleeding during, immediately and one day after the treatment which subsided during one week. A significant result shows less gingival inflammation in laser operculectomy than conventional operculectomy during two weeks following surgery (p value = 000). Most of the patients were satisfied with the laser removal of the operculum.

From this results Pain and discomfort in laser operculectomy is less than that in conventional surgery. There is no marked swelling around the tooth when operculectomy is done using laser. The area of surgery shows less inflammation and less healing duration when operculectomy is done using laser.

المستخلص

الغرض من هذه الدراسة هو تبيان كفاءة استخدام أشعة الليزر في التقنيات السريرية المستخدمة في جراحة الفصل ، مع الإشارة بشكل خاص إلى ليزرديود ذو الطول الموجي 980 نانومتر ومقارنته بالتقنية الجراحية التقليدية. تم إخضاع 10 مرضى. بإلتهاب الأنسجة حول تاج الضرس الثالث السفلي بالجهتين اليمنى واليسرى يتم علاجهم على مرحلتين في المرحلة الأولى تمت إزالة النسيج الملتهب حول سن واحد بواسطة ليزر ديود 980 نانومتر مع قوة 1.5-2 واط في الوضع الموجي المستمر. تمت إزالة النسيج الملتهب في الموقع الآخر لنفس المريض بعد أسبوعين من استئصال الجزء الأول باستخدام الجراحة التقليدية.

عانى جميع المرضى من الإحساس بالألم أثناء الجراحة الليزرية التي تلاشت أثناء وبعد جراحة استئصال النسيج بالليزر مباشرة .ثم بدأت مرة أخرى في اليوم الثاني من العلاج ثم تناقص الألم خلال فترة أسبوعين.

-شعر جميع المرضى بآلام بعد استئصال النسيج بعد الجراحة التقليدية مباشرة التي بدأت تنحسر خلال فترة أسبوعين.

-اتضح ان الآلام التي تلي علاج استخدام الليزر لإستئصال النسيج كانت بنسبة أقل من التي كانت بعد إستئصال بالجراحة التقليدية . (p value =000)

-لا يظهر الإستئصال الجراحي بالليزر أي تورم خلال فترة المتابعة بينماعملية إستئصال النسيج التقليدية تظهر إنتفاخًا خفيفًا بعد يوم من العملية الجراحية التي بدأت في التراجع.

-تقييم متوسط حجم التورم خلال فترة كاملة من الليزر ومقارنته بالجراحة التقليدية يظهرأن تورم النسيج يكون أقل في عملية الإستئصال بالليزر من الجراحة التقليدية. وهذه النتائج تعتبر ذات دلالة إحصائية مهمة .(p value = 000)

-أظهر مؤشر اللثة لإستئصال النسيج بالليزر نزيف خفيف مع لمس اللثة أثناء وبعد الجراحة الليزرية فوراً يختفي في اليوم التالي للعلاج.

-يظهر مؤشر اللثة بعد استئصال عملية استئصال النسيج التقليدية حدوث نزيف عفوي اثناء الجراحة وبعدها مباشرةً وبعد يوم واحد من العلاج الذي تناقص خلال أسبوع واحد.

-إن تقييم متوسط مؤشر اللثة خلال فترة العلاج بالليزر ومقارنتها بالجراحة التقليدية تظهر ان إلتهاب اللثة في جراحة إزالة النسيج بالليزر يكون أقل مقارنة بالجراحة التقليدية. . وهذه النتائج تعتبر

ذات دلالة إحصائية مهمة .(p value = 000)

-كان معظم المرضى راضين عن استخدام اليزر لعلاجهم أكثر من رضاؤهم عن الطريقة التقليدية.

من نتائج هذه الدراسة قد نستنتج أن الألم وعدم الراحة في إستئصال النسيج الملتهب حول الضرس الثالث بالليزر هو أقل من ذلك في الجراحة التقليدية.

-لا يوجد انتفاخ ملحوظ حول الأنسجة المحيطة بالضرس الثالث عندما تتم عملية الاستئصال بالليزر.

-تظهر منطقة الجراحة إلتهاب أقل كما أن مدة الشفاء تكون أقل في حال يتم إجراء جراحة ازالة النسيج الملتهب بالليزر مقارنة بالجراحة التقليدية.

-لا يؤثر ليزر الدايود على خصائص سطح الأسنان الهيكلي بشكل سلبي ، بغض النظر عن الطاقة المستخدمة.

-الحد من استخدام الليزر لإزالة النسيج الملتهب حول الضرس الثالث ترتبط في المقام الأول بتشريح الأنسجة الرخوة في المنطقة المحيطة وفوق السن وموضع السن.

-الحد من اللثة المرفقة من شأنه أن يحد من استخدام الليزر بسبب القضاء على الأنسجة الرخوة.

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CHAPTER ONE

Introduction

and

Literature Review.

Introduction and Literature Review.

1-1- Introduction:

1-1-1- History of laser:

In 1917, Albert Einstein established the theoretical foundations for the laser and the maser in the paper Zur Quantentheorie der Strahlung (On the Quantum Theory of Radiation) via a re-derivation of Max Planck's law of radiation, conceptually based upon probability coefficients (Einstein coefficients) for the absorption, spontaneous emission, and stimulated emission of electromagnetic radiation.) In 1928, Rudolf W. Ladenburg confirmed the existence of the phenomena of stimulated emission and negative absorption.(*Steen, W. M.(1998)*) In 1939, Valentin A. Fabrikant predicted the use of stimulated emission to amplify "short" waves. *(Batani, Dimitri (2004))* In 1947, Willis E. Lamb and R. C. Retherford found apparent stimulated emission in hydrogen spectra and effected the first demonstration of stimulated emission.(Steen, W. M.(1998) In 1950, Alfred Kastler who won Nobel Prize for Physics in 1966 proposed the method of optical pumping, experimentally confirmed, two years later, by Brossel, Kastler, and Winter.(*Ivar Waller (2007)*)

In 1957, Charles Hard Townes and Arthur Leonard Schawlow, then at Bell Labs, began a serious study of the infrared laser. As ideas developed, they abandoned infrared radiation to instead concentrate upon visible light. The concept originally was called an "optical maser". In 1958, Bell Labs filed a patent application for their proposed optical maser; and Schawlow and Townes submitted a manuscript of their theoretical calculations to the Physical Review. Simultaneously, at Columbia University, graduate student Gordon Gould was working on a doctoral thesis about the energy levels of excited thallium. When Gould and Townes met, they spoke of radiation emission, as a general subject; afterwards, in November 1957, Gould noted his ideas for a "laser", including using an open resonator (later an essential laser-device component). Moreover, in 1958, Prokhorov independently proposed using an open resonator, the first published appearance (in the USSR) of this idea. Elsewhere, in the U.S., Schawlow and Townes had agreed to an open-resonator laser design – apparently unaware of Prokhorov's publications and Gould's unpublished laser work.(*Chu, Steven* et. al. (2003))

At a conference in 1959, Gordon Gould published the term LASER in the paper The LASER, Light Amplification by Stimulated Emission of Radiation.*(Batani, Dimitri (2004)][Chu, Steven et. al 2003)* Gould's linguistic intention was using the "-aser" word particle as a suffix – to accurately denote the spectrum of the light emitted by the LASER device; thus x-rays:

xaser, ultraviolet: uvaser, etc; none established itself as a discrete term, although "raser" was briefly popular for denoting radio-frequency-emitting devices.(*Chu, Steven* et al 2003)

Gould's notes included possible applications for a laser, such as spectrometry, interferometry, radar, and nuclear fusion. He continued developing the idea, and filed a patent application in April 1959. The U.S. Patent Office denied his application, and awarded a patent to Bell Labs, in 1960. That provoked a twenty-eight-year lawsuit, featuring scientific prestige and money as the stakes. Gould won his first minor patent in 1977, yet it was not until 1987 that he won the first significant patent lawsuit victory, when a Federal judge ordered the U.S. Patent Office to issue patents to Gould for the optically pumped and the gas discharge laser devices. The question of just how to assign credit for inventing the laser remains unresolved by historians.(*Joan L. B. 1991*)

On May 16, 1960, Theodore H. Maiman operated the first functioning laser (*Maiman, T. H. (1960)*) (Townes et. al. 2008] at Hughes Research Laboratories, Malibu, California, ahead of several research teams, including those of Townes, at Columbia University, Arthur Schawlow, at Bell Labs,(*Hecht, Jeff et. al. (2005)*) and Gould, at the TRG (Technical Research Group) company. Maiman's functional laser used a solid-state flashlamp-pumped synthetic ruby crystal to produce red laser light, at 694 nanometers wavelength; however, the device only was capable of pulsed operation, because of its three-level pumping design scheme. Later that year, the Iranian physicist Ali Javan, and William R. Bennett, and Donald Herriott, constructed the first gas laser, using helium and neon that was capable of continuous operation in the infrared (U.S. Patent 3,149,290); later, Javan received the Albert Einstein Award in 1993. Basov and Javan proposed the semiconductor laser diode concept. In 1962, Robert N. Hall demonstrated the first laser diode device, made of gallium arsenide and emitting at 850 nm in the near-infrared band of the spectrum. Later that year, Nick Holonyak, Jr. demonstrated the first semiconductor laser with a visible emission. This first semiconductor laser could only be used in pulsed-beam operation, and when cooled to liquid nitrogen temperatures (77 K). In 1970, Zhores Alferov, in the USSR, and Izuo Hayashi and Morton Panish of Bell Telephone Laboratories also independently developed room-temperature, continual-operation diode lasers, using the heterojunction structure.(*Hecht, Jeff et al (2005)*)

1-1-2- Recent innovations:

Since the early period of laser history, laser research has produced a variety of improved and specialized laser types, optimized for different performance goals, including new wavelength bands, maximum average output power, maximum peak pulse energy, maximum peak pulse power, minimum output pulse duration, minimum linewidth, maximum power efficiency, and minimum cost. And this research continues to this day.

In 2017, researchers at TU Delft demonstrated an AC Josephson junction microwave laser.(*Phys.org. Retrieved(2017)*) Since the laser operates in the superconducting regime, it is more stable than other semiconductor-based lasers. The device has potential for applications in quantum computing.(*Cassidy, M. C et.al (2017)*) In 2017, researchers at TU Munich demonstrated the smallest mode locking laser capable of emitting pairs of phase-locked picosecond laser pulses with a repetition frequency up to 200 GHz.(ZMP 2017)

In 2017, researchers from the Physikalisch-Technische Bundesanstalt (PTB), together with US researchers from JILA, a joint institute of the National Institute of Standards and Technology (NIST) and the University of Colorado Boulder, established a new world record by developing an erbium-doped fiber laser with a linewidth of only 10 millihertz.(ZMP 2017])(*Matei, D. G et al. (2017)*)

1-1-3- Background:

Tremendous advances in the field of laser dentistry have occurred in the last years. Few years ago, dentists were just beginning to discover the usefulness of the erbium family of lasers on hard tissue. Today, those instruments are used for osseous surgeries and apisectomies and for operative dentistry on deciduous and permanent teeth. More laser companies are entering the field, offering the profession more choices, including more laser tips and similar accessories for performing more procedures than ever before. It is possible to perform different kinds of interventions on oral soft tissues in pediatric patients with efficient and fast techniques, minimizing, at the same time, intra and postoperative discomforts (*Nolen, Jim et al (2014), Csele, Mark (2004)*). The advantages of the laser are its great precision, its reliability and visual access of the area operated; the hemostasis control is definitely very high without the tissue suffering any harm due to uncontrollable spread of heat (Kotlow LA (2004)). The laser tip needs to be used in movement so as to prevent an increase of direct source energy. Next to delicate areas, as for example the periodontal area, it is advisable to operate the pulse mode. In this case, its efficacy is slightly slowed down, but tissue recovery is much faster (Saltzman B, et. al. (2005)). The hemostasis of the 810 nm laser is a consequence of its precision radiation absorption by hemoglobin and not to the typical electronic scalpel cauterizing action. The tissue injury is null and recovery is fast with reduced edema, inflammation and pain.

Laser aided interventions on oral soft tissue can be frequently performed without needing local anesthesia, but it is generally enough to use topical anesthesia, especially if laser energy is operated using the pulse mode (*Nolen, Jim et* al (2014)).

Treatment with diode laser is recommended in pediatric dentistry in all procedures of soft tissue surgery, as labial and lingual frenum, infections incisions, cheek or lip fibromas, flap opening of retained elements, gingival hypertrophy.

1-2- Literature Review:

1-2-3- **Definition of laser:** is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. The term "laser" originated as an acronym for "**light amplification by stimulated emission of radiation**"(Nelson JS, et. al. (1998)) (Kreisler M. (2005)]. The first laser was built in 1960 by Theodore H. Maiman at Hughes Research Laboratories, based on theoretical work by Charles Hard Townes and Arthur Leonard Schawlow. A laser differs from other sources of light in that it emits light coherently, spatially and temporally. Spatial coherence allows a laser to be focused to a tight spot, enabling applications such as laser cutting and lithography. Spatial coherence also allows a laser beam to stay narrow over great distances (collimation), enabling applications such as laser pointers. Lasers can also have high temporal coherence, which allows them to emit light with a very narrow spectrum, i.e., they can emit a single color of light. Temporal coherence can be used to produce pulses of light as short as a femto-second.

Among their many applications, lasers are used in optical disk drives, laser printers, and barcode scanners; DNA sequencing instruments, fiber-optic and free-space optical communication; laser surgery and skin treatments; cutting and welding materials; military and law enforcement devices for marking targets and measuring range and speed; and laser lighting displays in entertainment. Lasers are distinguished from other light sources by their coherence. Spatial coherence is typically expressed through the output being a narrow beam, which is diffraction-limited. Laser beams can be focused to very tiny spots, achieving a very high irradiance, or they can have very low divergence in order to concentrate their power at a great distance. Temporal (or longitudinal) coherence implies a polarized wave at a single frequency whose phase is correlated over a relatively great distance (the coherence length) along the beam.(Gould, R. et. al. *(1959).*) A beam produced by a thermal or other incoherent light source has an instantaneous amplitude and phase that vary randomly with respect to time and position, thus having a short coherence length.

Lasers are characterized according to their wavelength in a vacuum. Most "single wavelength" lasers actually produce radiation in several modes having slightly differing frequencies (wavelengths), often not in a single polarization. Although temporal coherence implies monochromaticity, there are lasers that emit a broad spectrum of light or emit different wavelengths of light simultaneously. There are some lasers that are not single spatial mode and consequently have light beams that diverge more than is required by the diffraction limit. However, all such devices are classified as "lasers" based on their method of producing light, i.e., stimulated emission. Lasers are employed in applications where light of the required spatial or temporal coherence could not be produced using simpler technologies.

1-2-4- Production of laser:

A laser consists of a gain medium, a mechanism to energize it, and something to provide optical feedback.(ZMP 2017) The gain medium is a material with properties that allow it to amplify light by way of stimulated emission. Light of a specific wavelength that passes through the gain medium is amplified (increases in power).

For the gain medium to amplify light, it needs to be supplied with energy in a process called pumping. The energy is typically supplied as an electric current or as light at a different wavelength. Pump light may be provided by a flash lamp or by another laser.

The most common type of laser uses feedback from an optical cavity, a pair of mirrors on either end of the gain medium. Light bounces back and forth between the mirrors, passing through the gain medium and being amplified each time. Typically one of the two mirrors, the output coupler, is partially transparent. Some of the light escapes through this mirror. Depending on the design of the cavity (whether the mirrors are flat or curved), the light coming out of the laser may spread out or form a narrow beam. In analogy to electronic oscillators, this device is sometimes called a laser oscillator. Most practical lasers contain additional elements that affect properties of the emitted light, such as the polarization, wavelength, and shape of the beam.

1-2-5- Laser physics

1-2-3-1- Stimulated emission

In the classical view, the energy of an electron orbiting an atomic nucleus is larger for orbits further from the nucleus of an atom. However, quantum mechanical effects force electrons to take on discrete positions in orbitals. Thus, electrons are found in specific energy levels of an atom, two of which are shown below. When an electron absorbs energy either from light (photons) or heat (phonons), it receives that incident quantum of energy. But transitions are only allowed in between discrete energy levels such as the two shown above. This leads to emission lines and absorption lines. When an electron is excited from a lower to a higher energy level, it will not stay that way forever. An electron in an excited state may decay to a lower energy state which is not occupied, according to a particular time constant characterizing that transition. When such an electron decays without external influence, emitting a photon, that is called "spontaneous emission". The phase associated with the photon that is emitted is random. A material with many atoms in such an excited state may thus result in radiation which is very spectrally limited (centered around one wavelength of light), but the individual photons would have no common phase relationship and would emanate in random directions. This is the mechanism of fluorescence and thermal emission.

An external electromagnetic field at a frequency associated with a transition can affect the quantum mechanical state of the atom. As the electron in the atom makes a transition between two stationary states (neither of which shows a dipole field), it enters a transition state which does have a dipole field, and which acts like a small electric dipole, and this dipole oscillates at a characteristic frequency. In response to the external electric field at this frequency, the probability of the atom entering this transition state is greatly increased. Thus, the rate of transitions between two stationary states is enhanced beyond that due to spontaneous emission. Such a transition to the higher state is called absorption, and it destroys an incident photon (the photon's energy goes into powering the increased energy of the higher state). A transition from the higher to a lower energy state, however, produces an additional photon; this is the process of stimulated emission.

1-2-3-2- Gain medium and cavity

The gain medium is put into an excited state by an external source of energy. In most lasers this medium consists of a population of atoms which have been excited into such a state by means of an outside light source, or an electrical field which supplies energy for atoms to absorb and be transformed into their excited states. ("laser". Reference.com (2008))

The gain medium of a laser is normally a material of controlled purity, size, concentration, and shape, which amplifies the beam by the process of stimulated emission described above. This material can be of any state: gas, liquid, solid, or plasma. The gain medium absorbs pump energy, which raises some electrons into higher-energy ("excited") quantum states. Particles can interact with light by either absorbing or emitting photons. Emission can be spontaneous or stimulated. In the latter case, the photon is emitted in the same direction as the light that is passing by. When the number of particles in one excited state exceeds the number of particles in some lower-energy state, population inversion is achieved and the amount of stimulated emission due to light that passes through is larger than the amount of absorption. Hence, the light is amplified. By itself, this makes an optical amplifier. When an optical amplifier is placed inside a resonant optical cavity, one obtains a laser oscillator.(Paul Hewitt, (2002).)

In a few situations it is possible to obtain lasing with only a single pass of EM radiation through the gain medium, and this produces a laser beam without any need for a resonant or reflective cavity (see for example nitrogen laser).(*Siegman (1986))* Thus, reflection in a resonant cavity is usually required for a laser, but is not absolutely necessary.

The optical resonator is sometimes referred to as an "optical cavity", but this is a misnomer: lasers use open resonators as opposed to the literal cavity that would be employed at microwave frequencies in a maser. The resonator typically consists of two mirrors between which a coherent beam of light travels in both directions, reflecting back on it so that an average photon will pass through the gain medium repeatedly before it is emitted from the output aperture or lost to diffraction or absorption. If the gain (amplification) in the medium is larger than the resonator losses, then the power of the recirculating light can rise exponentially. But each stimulated emission event returns an atom from its excited state to the ground state, reducing the gain of the medium. With increasing beam power the net gain (gain minus loss) reduces to unity and the gain medium is said to be saturated. In a continuous wave (CW) laser, the balance of pump power against gain saturation and cavity losses produces an equilibrium value of the laser power inside the cavity; this equilibrium determines the operating point of the laser. If the applied pump power is too small, the gain will never be sufficient to overcome the resonator losses, and laser light will not be produced. The minimum pump power needed to begin laser action is called the lasing threshold. The gain medium will amplify any photons passing through it, regardless of direction; but only the photons in a spatial mode supported by the resonator will pass more than once through the medium and receive substantial amplification. (Siegman (1986))

1-2-3-3- Continuous and pulsed modes of operation:

1-2-3-3-1- Continuous wave operation:

Some applications of lasers depend on a beam whose output power is constant over time. Such a laser is known as continuous wave (CW). Many types of lasers can be made to operate in continuous wave mode to satisfy such an application. Many of these lasers actually lase in several longitudinal modes at the same time, and beats between the slightly different optical frequencies of those oscillations will in fact produce amplitude variations on time scales shorter than the round-trip time (the reciprocal of the frequency spacing between modes), typically a few nanoseconds or less. In most cases these lasers are still termed "continuous wave" as their output power is steady when averaged over any longer time periods, with the very high frequency power variations having little or no impact in the intended application. (However the term is not applied to mode-locked lasers, where the intention is to create very short pulses at the rate of the round-trip time). For continuous wave operation, it is required for the population inversion of the gain medium to be continually replenished by a steady pump source. In some lasing media this is impossible. In some other lasers it would require pumping the laser at a very high continuous power level which would be impractical or destroy the laser by producing excessive heat. Such lasers cannot be run in CW mode.

1-2-3-3-2- Pulsed operation:

Pulsed operation of lasers refers to any laser not classified as continuous wave, so that the optical power appears in pulses of some duration at some repetition rate. This encompasses a wide range of technologies addressing a number of different motivations. Some lasers are pulsed simply because they cannot be run in continuous mode.

In other cases, the application requires the production of pulses having as large an energy as possible. Since the pulse energy is equal to the average power divided by the repetition rate, this goal can sometimes be satisfied by lowering the rate of pulses so that more energy can be built up in between pulses. In laser ablation, for example, a small volume of material at the surface of a work piece can be evaporated if it is heated in a very short time, while supplying the energy gradually would allow for the heat to be absorbed into the bulk of the piece, never attaining a sufficiently high temperature at a particular point.

Other applications rely on the peak pulse power (rather than the energy in the pulse), especially in order to obtain nonlinear optical effects. For a given pulse energy, this requires creating pulses of the shortest possible duration utilizing techniques such as Q-switching.

The optical bandwidth of a pulse cannot be narrower than the reciprocal of the pulse width. In the case of extremely short pulses, that implies lasing over a considerable bandwidth, quite contrary to the very narrow bandwidths typical of CW lasers. The lasing medium in some dye lasers and vibronic solid-state lasers produces optical gain over a wide bandwidth, making a laser possible which can thus generate pulses of light as short as a few femtoseconds (10^{-15} s)

1-2-3-3-2-1- Q-switching:

In a Q-switched laser, the population inversion is allowed to build up by introducing loss inside the resonator which exceeds the gain of the medium; this can also be described as a reduction of the quality factor or 'Q' of the cavity. Then, after the pump energy stored in the laser medium has approached the maximum possible level, the introduced loss mechanism (often an electro- or acousto-optical element) is rapidly removed (or that occurs by itself in a passive device), allowing lasing to begin which rapidly obtains the stored energy in the gain medium. This results in a short pulse incorporating that energy, and thus a high peak power.

1-2-3-3-3- Mode-locking

A mode-locked laser is capable of emitting extremely short pulses on the order of tens of picoseconds down to less than 10 femtoseconds. These pulses will repeat at the round trip time, that is, the time that it takes light to complete one round trip between the mirrors comprising the resonator. Due to the Fourier limit (also known as energy-time uncertainty), a pulse of such short temporal length has a spectrum spread over a considerable bandwidth. Thus such a gain medium must have a gain bandwidth sufficiently broad to amplify those frequencies. An example of a suitable material is titanium-doped, artificially grown sapphire (Ti:sapphire) which has a very wide gain bandwidth and can thus produce pulses of only a few femtoseconds duration.

Such mode-locked lasers are a most versatile tool for researching processes occurring on extremely short time scales (known as femtosecond physics, femtosecond chemistry and ultrafast science), for maximizing the effect of nonlinearity in optical materials (e.g. in second-harmonic generation, parametric down-conversion, optical parametric oscillators and the like). Due to the large peak power and the ability to generate phase-stabilized trains of ultrafast laser pulses, mode-locking ultrafast lasers underpin precision metrology and spectroscopy applications.(*Scientific American. 1974.*)

1-2-3-3-4- Pulsed pumping:

Another method of achieving pulsed laser operation is to pump the laser material with a source that is itself pulsed, either through electronic charging in the case of flash lamps, or another laser which is already pulsed. Pulsed pumping was historically used with dye lasers where the inverted population lifetime of a dye molecule was so short that a high energy, fast pump was needed. The way to overcome this problem was to charge up large capacitors which are then switched to discharge through flash lamps, producing an intense flash. Pulsed pumping is also required for three-level lasers in which the lower energy level rapidly becomes highly populated preventing further lasing until those atoms relax to the ground state. These lasers, such as the excimer laser and the copper vapor laser, can never be operated in CW mode.

1-2-3-4- Types and operating principles:

1-2-3-4-1- Gas lasers:

Following the invention of the HeNe gas laser, many other gas discharges have been found to amplify light coherently. Gas lasers using many different gases have been built and used for many purposes. The helium–neon laser (HeNe) is able to operate at a number of different wavelengths, however the vast majority are engineered to lase at 633 nm; these relatively low cost but highly coherent lasers are extremely common in optical research and educational laboratories. Commercial carbon dioxide (CO2) lasers can emit many hundreds of watts in a single spatial mode which can be concentrated into a tiny spot. This emission is in the thermal infrared at 10.6 µm; such lasers are regularly used in industry for cutting and welding. The efficiency of a CO2 laser is unusually high: over 30%.(*Karman, G. P. et. al. (1999)*) Argon-ion lasers can operate at a number of lasing transitions between 351 and 528.7 nm. Depending on the optical design one or more of these transitions can be lasing simultaneously; the most commonly used lines are 458 nm, 488 nm and 514.5 nm. A nitrogen transverse electrical discharge in gas at atmospheric pressure (TEA) laser is an inexpensive gas laser, often home-built by hobbyists, which produces rather incoherent UV light at 337.1 nm.(*Mayer, B. et. al. (2017)*) Metal ion lasers are gas lasers that generate deep ultraviolet wavelengths. Helium-silver (HeAg) 224 nm and neon-copper (NeCu) 248 nm are two examples. Like all low-pressure gas lasers, the gain media of these lasers have quite narrow oscillation linewidths, less than 3 GHz (0.5 picometers),(*Covina, Calif. et. al.(2007)*) making them candidates for use in fluorescence suppressed Raman spectroscopy.

1-2-3-4-2- Chemical lasers:

Chemical lasers are powered by a chemical reaction permitting a large amount of energy to be released quickly. Such very high power lasers are especially of interest to the military; however continuous wave chemical lasers at very high power levels, fed by streams of gasses, have been developed and have some industrial applications. As examples, in the hydrogen fluoride laser (2700–2900 nm) and the deuterium fluoride laser (3800 nm) the reaction is the combination of hydrogen or deuterium gas with combustion products of ethylene in nitrogen trifluoride.

1-2-3-4-3- Excimer lasers:

Excimer lasers are a special sort of gas laser powered by an electric discharge in which the lasing medium is an excimer, or more precisely an exciplex in existing designs. These are molecules which can only exist with one atom in an excited electronic state. Once the molecule transfers its excitation energy to a photon, therefore, its atoms are no longer bound to each other and the molecule disintegrates. This drastically reduces the population of the lower energy state thus greatly facilitating a population inversion. Excimers currently used are all noble gas compounds; noble gasses are chemically inert and can only form compounds while in an excited state. Excimer lasers typically operate at ultraviolet wavelengths with major applications including semiconductor photolithography and LASIK eye surgery. Commonly used excimer molecules include ArF (emission at 193 nm), KrCl (222 nm), KrF (248 nm), XeCl (308 nm), and XeF (351 nm).(*Schuocker, D. (1998).*) The molecular fluorine laser, emitting at 157 nm in the vacuum ultraviolet is sometimes referred to as an excimer laser, however this appears to be a misnomer inasmuch as F2 is a stable compound.

1-2-3-4-4- Solid-state lasers:

Solid-state lasers use a crystalline or glass rod which is "doped" with ions that provide the required energy states. For example, the first working laser was a ruby laser, made from ruby (chromium-doped corundum). The population inversion is actually maintained in the dopant. These materials are pumped optically using a shorter wavelength than the lasing wavelength, often from a flashtube or from another laser. The usage of the term "solid-state" in laser physics is narrower than in typical use. Semiconductor lasers (laser diodes) are typically not referred to as solid-state lasers.

Neodymium is a common dopant in various solid-state laser crystals, including yttrium orthovanadate (Nd:YVO4), yttrium lithium fluoride (Nd:YLF) and yttrium aluminium garnet (Nd:YAG). All these lasers can produce high powers in the infrared spectrum at 1064 nm. They are used for cutting, welding and marking of metals and other materials, and also in spectroscopy and for pumping dye lasers. These lasers are also commonly frequency doubled, tripled or quadrupled to produce 532 nm (green, visible), 355 nm and 266 nm (UV) beams, respectively. Frequency-doubled diode-pumped solid-state (DPSS) lasers are used to make bright green laser pointers.

Ytterbium, holmium, thulium, and erbium are other common "dopants" in solid-state lasers.[(Bass, Michael. Et. al. (2009))] Ytterbium is used in crystals such as Yb:YAG, Yb:KGW, Yb:KYW, Yb:SYS, Yb:BOYS, Yb:CaF2, typically operating around 1020–1050 nm. They are potentially very efficient and high powered due to a small quantum defect. Extremely high powers in ultrashort pulses can be achieved with Yb:YAG. Holmium-doped YAG crystals emit at 2097 nm and form an efficient laser operating at infrared wavelengths strongly absorbed by water-bearing tissues. The Ho-YAG is usually operated in a pulsed mode, and passed through optical fiber surgical devices to resurface joints, remove rot from teeth, vaporize cancers, and pulverize kidney and gall stones.

Titanium-doped sapphire (Ti:sapphire) produces a highly tunable infrared laser, commonly used for spectroscopy. It is also notable for use as a mode-locked laser producing ultrashort pulses of extremely high peak power.

Thermal limitations in solid-state lasers arise from unconverted pump power that heats the medium. This heat, when coupled with a high thermo-optic coefficient (dn/dT) can cause thermal lensing and reduce the quantum efficiency. Diode-pumped thin disk lasers overcome these issues by having a gain medium that is much thinner than the diameter of the pump beam. This allows for a more uniform temperature in the material. Thin disk lasers have been shown to produce beams of up to one kilowatt.[(C. Stewen (2000))].

1-2-3-4-5- Fiber lasers:

Solid-state lasers or laser amplifiers where the light is guided due to the total internal reflection in a single mode optical fiber are instead called fiber lasers. Guiding of light allows extremely long gain regions providing good cooling conditions; fibers have high surface area to volume ratio which allows efficient cooling. In addition, the fiber's wave guiding properties tend to reduce thermal distortion of the beam. Erbium and ytterbium ions are common active species in such lasers.

Quite often, the fiber laser is designed as a double-clad fiber. This type of fiber consists of a fiber core, an inner cladding and an outer cladding. The index of the three concentric layers is chosen so that the fiber core acts as a single-mode fiber for the laser emission while the outer cladding acts as a highly multimode core for the pump laser. This lets the pump propagate a large amount of power into and through the active inner core region, while still having a high numerical aperture (NA) to have easy launching conditions. Pump light can be used more efficiently by creating a fiber disk laser, or a stack of such lasers. Fiber lasers have a fundamental limit in that the intensity of the light in the fiber cannot be so high that optical nonlinearities induced by the local electric field strength can become dominant and prevent laser operation and/or lead to the material destruction of the fiber. This effect is called photodarkening. In bulk laser materials, the cooling is not so efficient, and it is difficult to separate the effects of photodarkening from the thermal effects, but the experiments in fibers show that the photodarkening can be attributed to the formation of long-living color centers.

1-2-3-4-6- Photonic crystal lasers:

Photonic crystal lasers are lasers based on nano-structures that provide the mode confinement and the density of optical states (DOS) structure required for the feedback to take place. They are typical micrometer-sized (dubious – discuss) and tunable on the bands of the photonic crystals.(*Wu, X.; et al.(2004)*)

1-2-3-4-7- Semiconductor lasers:

Semiconductor lasers are diodes which are electrically pumped. Recombination of electrons and holes created by the applied current introduces optical gain. Reflection from the ends of the crystal form an optical resonator, although the resonator can be external to the semiconductor in some designs.

Commercial laser diodes emit at wavelengths from 375 nm to 3500 nm.(*Hanel Photonics.(2014)*) Low to medium power laser diodes are used in laser pointers, laser printers and CD/DVD players. Laser diodes are also frequently used to optically pump other lasers with high efficiency. The highest power industrial laser diodes, with power up to 10 kW (70 dBm)[are used in industry for cutting and welding. External-cavity semiconductor lasers have a semiconductor active medium in a larger cavity. These devices can generate high power outputs with good beam quality, wavelength-tunable narrow-linewidth radiation, or ultrashort laser pulses..In 2012, Nichia and OSRAM developed and manufactured commercial high-power green laser diodes (515/520 nm), which compete with traditional diode-pumped solid-state lasers.(*nichia.co.jp.*(2012)) *(osram-os.com.(2015)*)

Vertical cavity surface-emitting lasers (VCSELs) are semiconductor lasers whose emission direction is perpendicular to the surface of the wafer. VCSEL devices typically have a more circular output beam than conventional laser diodes. As of 2005, only 850 nm VCSELs are widely available, with 1300 nm VCSELs beginning to be commercialized,(VCSELs (2006)) and 1550 nm devices an area of research. VECSELs are external-cavity VCSELs. Quantum cascade lasers are semiconductor lasers that have an active transition between energy sub-bands of an electron in a structure containing several quantum wells.

The development of a silicon laser is important in the field of optical computing. Silicon is the material of choice for integrated circuits, and so electronic and silicon photonic components (such as optical interconnects) could be fabricated on the same chip. Unfortunately, silicon is a difficult lasing material to deal with, since it has certain properties which block lasing. However, recently teams have produced silicon lasers through methods such as fabricating the lasing material from silicon and other semiconductor materials, such as indium (III) phosphide or gallium (III) arsenide, materials which allow coherent light to be produced from silicon. These are called hybrid silicon laser. Recent developments have also shown the use of monolithically integrated nanowire lasers directly on silicon for optical interconnects, paving the way for chip level applications.(*Mayer, B. et. al.(2016)*) These heterostructure nanowire lasers capable of optical interconnects in silicon are also capable of emitting pairs of phase-locked picosecond pulses with a repetition frequency up to 200 GHz, allowing for on-chip optical signal processing.("ZMP 2017) Another type is a Raman laser, which takes advantage of Raman scattering to produce a laser from materials such as silicon.

Lasing without maintaining the medium excited into a population inversion was demonstrated in 1992 in sodium gas and again in 1995 in rubidium gas by various international teams.(*Mompart, J. et. al. (2000)*)[*Javan, A. (2000))*] This was accomplished by using an external maser to induce "optical transparency" in the medium by introducing and destructively interfering the ground electron transitions between two paths, so that the likelihood for the ground electrons to absorb any energy has been cancelled.

1-2-3-4-8- Dye lasers:

Dye lasers use an organic dye as the gain medium. The wide gain spectrum of available dyes, or mixtures of dyes, allows these lasers to be highly tunable, or to produce very short-duration pulses (on the order of a few femtoseconds). Although these tunable lasers are mainly known in their liquid form, researchers have also demonstrated narrow-linewidth tunable emission in dispersive oscillator configurations incorporating solid-state dye gain media.(*Javan, A. (2000).*) In their most prevalent form these solid state dye lasers use dye-doped polymers as laser media.

1-2-3-4-9- Free-electron lasers:

Free-electron lasers, or FELs, generate coherent, high power radiation that is widely tunable, currently ranging in wavelength from microwaves through terahertz radiation and infrared to the visible spectrum, to soft X-rays. They have the widest frequency range of any laser type. While FEL beams share the same optical traits as other lasers, such as coherent radiation, FEL operation is quite different. Unlike gas, liquid, or solid-state lasers, which rely on bound atomic or molecular states, FELs use a relativistic electron beam as the lasing medium, hence the term free-electron.(*F. J. Duarte, et. al (2015)*)

1-2-3-4-10- Exotic media:

The pursuit of a high-quantum-energy laser using transitions between isomeric states of an atomic nucleus has been the subject of wide-ranging academic research since the early 1970s. Much of this is summarized in three review articles.(Baldwin, G. C et. al (1981)][Baldwin, G. C et. al. (1995)][*Baldwin, G. C. et. al (1997)*) This research has been international in scope, but mainly based in the former Soviet Union and the United States. While many scientists remain optimistic that a breakthrough is near, an operational gamma-ray laser is yet to be realized.(*Baldwin, G. C. et. al.(1982)*)

Some of the early studies were directed toward short pulses of neutrons exciting the upper isomer state in a solid so the gamma-ray transition could benefit from the linenarrowing of Mössbauer effect.(*Solem, J. C. (1979).*([*Baldwin, G. C.et. al. (1979)*) In conjunction, several advantages were expected from two-stage pumping of a three-level system.(*Baldwin, G. C. et. al. (1980)*) It was conjectured that the nucleus of an atom, embedded in the near field of a laser-driven coherently-oscillating electron cloud would experience a larger dipole field than that of the driving laser. (*Solem, J. C. (1986)*) (*Biedenharn, L. C.et. al. (1986)*] Furthermore, nonlinearity of the oscillating cloud would produce both spatial and temporal harmonics, so nuclear transitions of higher multipolarity could also be driven at multiples of the laser frequency.(*Rinker, G. A. (1988)*][*Rinker, G. A.(1979)*][*Solem, J. C. (1988).*][*Solem, J. C. et. al. (1987)*][*Solem, J. C.. et. al. (1988)*][*Boyer, K.et. al (1987)*][*Biedenharn, L. C.(1989)*]

Space-based X-ray lasers pumped by a nuclear explosion have also been proposed as antimissile weapons.(*Hecht, (2008)*.][*Robinson. (1981).*) Such devices would be one-shot weapons.

Living cells have been used to produce laser light.(*Hecht, (2008)*][*Fildes (2007)*] The cells were genetically engineered to produce green fluorescent protein (GFP). The GFP is used as the laser's "gain medium", where light amplification takes place. The cells were then placed between two tiny mirrors, just 20 millionths of a meter across, which acted as the "laser cavity" in which light could bounce many times through the cell. Upon bathing the cell with blue light, it could be seen to emit directed and intense green laser light.

Lasers have many uses in medicine, including laser surgery (particularly eye surgery), laser healing, kidney stone treatment, ophthalmoscopy, and cosmetic skin treatments such as acne treatment, cellulite and striae reduction, and hair removal.

1-2-6- Laser- Tissue Interaction:

Generally, laser radiation affects that kind of tissue, which absorbs the radiation. The absorption of laser radiation in tissue, especially in oral tissue, is strongly wavelength dependent. The type of interaction depends on the wavelength and on the interaction duration..The type of interaction of laser radiation with tissue will be determined by the interaction duration on the one hand and the irradiance on the other. For instance, photochemical interaction mechanisms are dominant for low irradiance, long term exposure, while nonlinear effects only occur for short pulse,high irradiance exposure[(*Palmer* (2011))].

1-2-4-1- Thermal Interaction: The term thermal interaction stands for a large group of interaction types, where the increase in local temperature is the significant parameter change.Thermal effects can be induced by either CW or pulsed laser radiation. While photochemical processes are often governed by a specific reaction pathway, thermal effects generally tend to be nonspecific according to Parrish and Deutsch (1984). However, depending on the duration and peak value of the tissue temperature achieved, different effects like coagulation, vaporization, carbonization.

1-2-4-2- Coagulation. The histologic appearance of coagulated tissue during which, temperatures reach at least 60◦C, and coagulated tissue becomes necrotic as will be discussed in this section.

1-2-4-3- Vaporization. during the ablation process, complete layers of tooth substance were removed leaving stair-like structures.

1-2-4-4- Carbonization. the local temperature of the exposed tissue had been drastically increased. At temperatures above approximately 100◦C, the tissue starts to carbonize, i.e. carbon is released, leading to a blackening in color. carbonization should be avoided in any case, since tissue already becomes necrotic at lower temperatures. Thus, carbonization only reduces visibility during surgery.

1-2-4-5- Melting. originate from thermal stress induced by a local temperature gradient across the tooth surface. [(*Medline Plus (2017)*]].

1-2-7- Safety:

Even the first laser was recognized as being potentially dangerous. Theodore Maiman characterized the first laser as having a power of one "Gillette" as it could burn through one Gillette razor blade. Today, it is accepted that even low-power lasers with only a few milliwatts of output power can be hazardous to human eyesight when the beam hits the eye directly or after reflection from a shiny surface. At wavelengths which the cornea and the lens can focus well, the coherence and low divergence of laser light means that it can be focused by the eye into an extremely small spot on the retina, resulting in localized burning and permanent damage in seconds or even less time.

Lasers are usually labeled with a safety class number, which identifies how dangerous the laser is:

- Class 1 is inherently safe, usually because the light is contained in an enclosure, for example in CD players.
- Class 2 is safe during normal use; the blink reflex of the eye will prevent damage. Usually up to 1 mW power, for example laser pointers.
- Class 3R (formerly IIIa) lasers are usually up to 5 mW and involve a small risk of eye damage within the time of the blink reflex. Staring into such a beam for several seconds is likely to cause damage to a spot on the retina.
- Class 3B can cause immediate eye damage upon exposure.
- Class 4 lasers can burn skin, and in some cases, even scattered light can cause eye and/or skin damage. Many industrial and scientific lasers are in this class.

The indicated powers are for visible-light, continuous-wave lasers. For pulsed lasers and invisible wavelengths, other power limits apply. People working with class 3B and class 4 lasers can protect their eyes with safety goggles which are designed to absorb light of a particular wavelength (*"Lasers in Cancer Treatment".(2011))*.

Infrared lasers with wavelengths longer than about 1.4 micrometers are often referred to as "eye-safe", because the cornea tends to absorb light at these wavelengths, protecting the retina from damage. The label "eye-safe" can be misleading, however, as it applies only to relatively low power continuous wave beams; a high power or Q-switched laser at these wavelengths can burn the cornea, causing severe eye damage, and even moderate power lasers can injure the eye. (*"Lasers in Cancer Treatment".(2011))* .]

1-2-8- Laser uses in Medicine:

1- Lasers are used to treat cancer by shrinking or destroying tumors or precancerous growths. They are most commonly used to treat superficial cancers that are on the surface of the body or the lining of internal organs. They are used to treat basal cell skin cancer and the very early stages of others like cervical, penile, vaginal, vulvar, and non-small cell lung cancer. Laser therapy is often combined with other treatments, such as surgery, chemotherapy, or radiation therapy. Laser-induced interstitial thermotherapy (LITT), or interstitial laser photocoagulation, uses lasers to treat some cancers using hyperthermia, which uses heat to shrink tumors by damaging or killing cancer cells. Laser are more precise than surgery and cause less damage, pain, bleeding, swelling, and scarring. A disadvantage is that surgeons must have specialized training. It may be more expensive than other treatments.(*http://www.clicktoconvert.com*) (*Markolf H*).

1-2-9- Laser uses in Dentistry:

Laser used in dental practice in two brands, soft tissue managements and hard tissue management.depending on the mechanism of laser tissue interaction.(*Zegarelli EV,(1978*0

The Diode laser is an example of soft tissue laser and has been used in many brands of dentistry:

1-2-7-1- Labial frenum:

The upper labial frenum usually goes from the upper or lower labial vestibules till the incisal area next to the interdental area between the two central incisors next to the mucogingival junction. The hypertrophy of the labial frenum looks like a thick tissue that anchors the upper lip mucosa to the end of the alveolar bone and the interdental papilla between the two central incisors and, in some cases, to the adherent palatal gingiva (*Zegarelli EV et. al ,(1978)0]*(*Matsumoto K, (2002)*).

Complications associated to the hypertrophy of the upper labial frenum can be orthodontic, such as interdental diastema, a periodontal, with predisposition to develop gingival recession or functional recession, dealing with a bad oral hygiene. (*Koerner KR, et. al. (1994)*).

The labial frenectomy procedure is recommended whenever a pathologic interdental diastema or/and a periodontal risk of losing mucogingival tissue is present (*Koerner KR, et a (1994)*).

The aim of this surgical procedure is that of repositioning the frenum apically to the mucogingival line eliminating the interdental fibrous membrane. Frenectomy is performed with 810 nm diode laser with a power of 1.6-2.5 W in continuous mode using a fiber of 320/400 μm. The technique foresees the removal of the frenum starting from the interdental insertion moving towards the apex direction, parallel to the tooth axis. Afterwards, the interdental papilla is incised till the periosteum is reached. Thanks to the hemostasis condition caused by the diode laser, suture is not needed, and thus, recovery is awaited as per second intention. Complete healing takes place after about two weeks from surgery (Gontijo I, et al. (2005)0. Compared to traditional surgery, which also foresees healing by second intention of the bone portion of the surgery injury, after frenectomy with diode laser, patients generally report little discomforts during the healing time. The lower labial frenum attaches, from the inner part of the lower lip to the interdental papilla or apically of it (Gontijo I, et. al. (2005)).

When the insertion of this frenum is in a coronal position compared to the mucogingival line it can predispose to the development of periodontal complications, particularly in case it is associated to a thin layer of keratinized gingival (*Koerner KR, et. al. (19940*],(Gontijo I, et. al. (2005)). When gingival recession has been observed, the frenum seems to be a worsening factor. The laser aided surgery technique for lower labial frenum foresees the same steps as for the upper frenum. According to some authors experience 9*Einstein, A (1917)]*,[Gontijo I, et. al. (2005)), (Stabholz A, et. al. (2004)), to perform labial frenectomy with diode laser in pediatric patients, after topical anesthesia, it is necessary to infiltrate about 0.5 ml of anesthesia without vasoconstrictor at the level of the vestibule so as to reduce to the minimum pain sensibility that can develop, particularly during recession of the deep connective fibers at the level of the periosteum. It is not advisable to supply anesthesia directly on the frenum area, so as not to alter its shape and dimension. It is not recommended to use vasoconstrictors in order to avoid a condition of ischemia that would render less efficient the interaction between wavelength of the diode laser radiation (810 nm) and tissue (Stabholz A, et. al. (2004)).

1-2-7-2- Lingual frenum:

The lingual frenum is a fold of mucous membrane extending from the ventral surface of the tongue to the floor of the mouth. The situation in which the lingual frenum is short and hypertrophic is called ankyloglossia. Ankyloglossia can condition normal suction, swallowing and phonetics in children, influencing, thus, during time, the development of the jawbone and dental position, for both the atypical contemporary swallowing to come and for the traction strength to follow. This condition can, this way, predispose to the development of orthodontic and phonetic problems (Koch G, et. al. (2009)).

The technique of lingual frenum removal with 810 nm diode laser is performed with a fiber of 320-400 μm and a power of 1.8-3W in continuous mode, through mobilization of the lingual corpse and rhomboidal cutting following anatomic levels (*Einstein, A (1917).* (Crippa R, et. al. (2008)),(Fernando C. et. al. (1998)), generally without infiltration of anesthesia and with only topical administration, recovery is reached by second intention and without any surgical suture. Immediately after the operation, the mobility of the tongue acquires physiological characteristics during the recovery period that lasts about two weeks. Patients will need to do exercises of the mobility of the tongue to prevent relapse and then start, eventually, logaoedic rehabilitation (Fernando C et. al. (1998)).

1-2-7-3- Gingival hypertrophy:

Gingival hypertrophy is represented by an increase in the size of the gingiva linked to an increased number of cells that can be due to different causes, as irritation (iatrogenic or associated to bad habits), hormonal influences or side effects during drug therapies. Hereditary or idiopathic forms are also generalized or locally identified in only some sites (Bimstein E, et. al. (2001))

In many cases, tissue hypertrophy does not remit spontaneously after resolution of the causing agent, and thus, it is needed to surgically address the clearing of hypertrophic tissue in order to solve esthetic issues or, in some cases, orthodontic ones. Gingvectomy with 810 nm diode laser shows different advantages compared to traditional surgery, limiting anesthesia to the topical administration (Bimstein E, et. al. (2001)). The postoperative period has shown to present no discomfort for patients. Cutting within a hemostasis environment renders the operation easy and precise in what the definition of gingival contour regards, especially in an esthetic area, and most of all, it guarantees a safe treatment in terms of potential iatrogenic damages. These issues, which are frequent after electrical scalpel, are caused by tissue retraction during postoperative healing. This treatment is performed with 810 nm diode laser on continuous mode at a power of 1-2,5 watt using a fiber of 320-400 μm (Bimstein E, et. al. (2001)).

1-2-7-4- Hypertrophic lesions:

Diode laser has shown to be, since its introduction, particularly recommended in oral soft tissues surgery, specifically regarding benign lesions. Oral soft tissue benign new formations in children are generally mucous cysts at a labial level or connective fibromas, normally sited at the buccal mucosa. These are due to proliferation of fibroblasts after repeated bite trauma or lesions due to orthodontic devices (Goharkhay K, et. al. (1999)], [Maggioni M, et. al.(2009)). The use of a diode laser allows you to remove the new formation, whether it presents a sessile or peduncle form, without needing surgical suture and without scar resulting from healing. In some cases, besides topical anesthesia a mild infiltration of anesthesia can be applied with no vasoconstriction at the lesion base, especially when is situated in sensible areas (Olivi G, et. al. (2007)). The treatment is performed with a 810 nm diode laser with a fiber of 320-400 μm and at 2,5-4 W power in continuous mode. After removal of the new formation, the surgical wound area, normally not bleeding, heals by second intention and patients are controlled for follow-up at 1 and 2 weeks or, in any case, till complete tissue recovery. During the healing process the patient discomfort in the scar tissue area is usually very acceptable in comparison to conventional surgery techniques.

1-2-7-5- Tooth retention:

The operculectomy or surgical excision of the mucosa over an unerupted tooth with a laser light presents undoubtful practical advantages. In traditional surgery, the operculum opening that is to allow the dental element to show up is performed after local anesthesia and scalpel or electronic scalpel cutting, according to the site, depth and mucosa thickness. Hemostasis control may be problematic and surgical suture is often needed (*MedlinePlus (2017)*]. With diode laser the intervention is far more comfortable, less invasive and traumatic. The most vascularized areas are surgically easy to treat due to the high visibility of the operating area which normally does not bleed. The operation is performed with a 810 nm diode laser with a fiber of 320-400 μm and at a power of 1.6 -3 Watt in continuous mode (*MedlinePlus (2017)*)..

1-3- **Pericoronitis:**

Pericoronitis is an inflammatory condition that may accompany eruption of teeth, particularly around mandibular third molars. It may be associated with traumatic occlusion with its maxillary counterpart that often complicates the existing pathology by repeated cheek biting and consequent localized reactive proliferation of buccal mucosa. The inflamed operculum covering the partially or completely erupted mandibular third molar may get infected by microbial flora, predominantly anaerobes as it is often less accessible to routine oral hygiene activities.[(Sixou JL, et. al (2003))] In most cases, the symptoms are mild and infrequent, However, exacerbation of inflammation may lead to abscess formation and/or lymphadenitis and subsequent spread to facial spaces requiring immediate intervention. Associated symptoms often observed are fever, severe pain, trismus and difficulty in speech or deglutition, depending on the extent and severity of the condition [(Kay LW.(1966))].

Management of such conditions include relieving occlusion from maxillary third molar, drainage of abscess, thorough debridement of tooth surface and removal of pocket lining. It is necessary to ensure that areas around offending teeth are accessible to cleaning by routine oral hygiene aids so as to prevent the recurrence of infection. For that purpose, operculectomy and excision of proliferative growth from buccal mucosa is often required. Conventional excision with scalpel is an established method of operculectomy that may be performed under local anesthesia. However, intraoperative bleeding may obliterate the operating field, and increase the chair-side time. Further, this technique results in secondary healing of wound, which is delayed and painful. Healing is often associated with trismus that affects the routine life of the patient. The soft-tissue diode lasers have an excellent incision performance with a cutting depth of 2 to 6 mm and have an added advantage over conventional surgery in that there is sealing of small blood and lymphatic vessels resulting in hemostasis and reduced postoperative edema.[(Sarver DM,(2005))] Target tissues are also disinfected as a result of irradiation and local heating.[(Ize-Iyamu IN, et. al. (2013))] There is decreased amount of scarring due to decreased postoperative tissue shrinkage .[(Sarver DM, et. al (2005)), (Ize-Iyamu IN, et. al. (2013))] Consequently, the use of sutures is also eliminated in most of the cases.[(Chawla K, et. al (2014)) (Pick RM, 1983))] Levine R1, et al reported that The 10,600-nm CO_2 laser is both an efficient and spatially precise photo-thermal ablation device and excellent coagulator because of the close match between its coagulation depth and the diameters of oral soft-tissue capillaries. The ablation of hyperplastic oral soft tissue with the flexible fiber waveguide 10,600-nm CO_2 laser is a minimally invasive and typically suture-free surgical modality that ensures dependable treatment. It is, in many respects, superior to most of the alternative treatment options. Its excellent hemostatic abilities and the minimal damage to adjacent healthy tissues make the CO_2 laser a perfect surgical tool for treating oral soft-tissue lesions, including the inflamed operculum (Levine R1, et. al. (2015)). Abdul Ahad et al. reported that Pericoronitis with its acute exacerbation requires prompt intervention. Although it has been treated successfully with conventional mechanical debridement and operculectomy, GaAlAs diode lasers offer minimal invasive way with less patient morbidity to achieve similar outcome in relatively shorter duration. It can be incorporated in routine periodontal practice for better patient acceptance (Abdul Ahad, Shruti T, et. al. (2014)).

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1-4- Justification:

- Laser is a technique that is recently introduced in Sudan as a tool of periodontal surgery and we need to identify its advantages to conventional methods.
- Furthermore, the number of researches that had been conducted to Laser system in Sudan are few, justifying carrying such a study.

1-5- Research Question: Is there any difference between laser and conventional periodontal surgery?

1-6- Problem Statement: Lack of knowledge of the laser uses in operculectomy and the difference between it and the conventional surgery is usually overlooked in the remedy of periodontal surgery therefore impeding the treatment and/or complicate the treatment period. In addition knowledge of the ease of the laser therapy by the patients themselves may lead them to avoid the complication of non treating the problem itself and hence may enhance no complications of pericoronal inflammation.

1-7- Objectives:

1-7-1 General objectives:

This research is designed to assess the efficiency of the use of diode laser in periodontal surgery techniques used in operculectomy,

1-7-2- Specific objectives:

- To measure the pain perception during and after operation.
- To measure the post operative swelling by the patient
- To measure the post operative gingival inflammation and healing.
- To assess the patient satisfaction of the operation using questionnaire**.**

CHAPTER TWO

Materials

and

method

Materials and method

2-1- Study design: Clinical trial study.

2-2- Study area: The study was conducted at Al-Muddathir Dental Implantology Clinic in Khartoum.

2-3- Study duration: The study was carried out in the period from 2nd of January to 31st of March 2018.

2-4- Sample size:

- Ten adults patients with bilateral pericoronitis participated in this study. Each of them was treated with phase 1 therapy for the inflamed area.
- Written consent was given to all patients before the treatment

2-5- Data collection tools:

2-5-1- Medical Laser system Programs:

- The laser device (Quicklase -Britain) was used in this study.

- Laser specification:

Laser	Diode
Wavelength	980 nm(+10nm)
Laser max output power	10 Watt
Operation mode	continuous wave (cw)/pulsed
Timer	1 s -5 min
Delivery of the beam	optical fiber
Spot size	variable (fiber size, hand piece)
Monitored power	+10% output power
Actuator	foot switch
Aiming beam	Red

2-5-2- Preparations to switch the laser on:

- All laser systems have their ideal indications.

- Quicklase lasers, however, are extremely versatile and therefore amortize themselves quickly.

- A laser treatment does not require any special preparations, according to the recallable programs this laser system is particularly easy to handle.

- All safety measures were done.

- Procedures and techniques:

- Topical anesthesia applied to the patient at the site of the operculum.

- A local anesthesia was administered when the patient still experienced pain.
- The location of the operculum was estimated.
- Then the operculum around the tooth was by diode laser 980nm using a 300micron initiated fiber and continuous wave energy for 15- 20 seconds to remove tissue without charring (usually1.5- 2Watts) by ablating the soft tissue above it.
- The procedure was completed in less than 10 minutes, and no sutures were used, no periodontal dressings were applied and no medications were prescribed.
- The operculum in the opposite site of the same patient was removed after two weeks from the laser operculectomy using the conventional surgery.
- **2-5-3- Conventional operculectomy tools and technique:**

The opposing operculum is removed by using scalpel size 15c and periodontal curette and distal molar flap surgery is done with suturing by using 4/0 non resorbable silk suture using interrupted suture technique. The sutures were removed after one week of the surgery.

- The followings characters were recorded from the patients during, immediately after, one day after, two days after, three days after, one week after and two weeks after the two operations:
- Pain: using Verbal pain scale table (Disabled World. 2018)).

0	**1 -3**	**4 – 6**	**7 – 9**	**10**
No pain	**Mild pain**	**Moderate pain**	**Severe pain**	**Un tolerable pain**

- The degree of gingival swelling can be scored as follows: (Buchner A, et. al. (1979))
    - Grade 0: No signs of gingival swelling.
    - Grade I: swelling confined to interdental papilla.
    - Grade II: swelling involves papilla and marginal gingiva.
    - Grade III: swelling covers three quarters or more of the crown.
- Gingival index. (Löe and Silness. 1963) as a method for assessing the severity and quantity of gingival inflammation[Loe H. et. al. (1967)], [,Loe H, et. al. (1963)].

0	1	2	3
No inflammation	inflammation with no bleeding	provoked bleeding	spontaneous bleeding

- Patient satisfaction : by comparing which technique is preferred by the patient.

2-6- Data Analysis:-

- Data were analyzed using SPSS version 23.
- Comparison according to pain, swelling, plaque, and gingival Index, is done using two way repeated measure Chi square test.

2-7- Data presentation:-

Informations obtained were presented graphically through tabulation.

2-8- Ethical Consideration:-

- Patient consent (written – Annex III).
- All patients found in need for treatment were treated in the clinic.

CHAPTER THREE

Results and Discussion

3-1-Results

- Ten adults patients in this field study consisted of seven females and three males of different age groups. The distribution is shown in (Table 1).
- The patients were complaining of acute form of pericoronitis episodes 1 to 4 times per year were 30% and with the episodes of to 8 times a year were 70% (Table 2).
- All patients suffered from pain before treatment, (Table 3).
- All patients experienced a sensation of pain during the laser surgery which subsides during and immediately after the laser operculectomy. And then started again at the second day of the treatment then it subsided during period of two weeks (Table 4).
- All patients experienced sever post operative pain immediately after the conventional operculectomy. This started to subside during period of two weeks (Table 5).
- (Table 6) shows the evaluation of mean pain scale during the whole period of laser in comparison with conventional surgery with significant result shows less pain in laser operculectomy procedures.
- In laser operculectomy No swelling is shown during the period of follow up. (Table 7).while in conventional operculectomy there was mild swelling one day post operatively which started to be subsided.(Table 8)
- (Table 9) shows the evaluation of mean swelling size during the whole period of laser and compares it with conventional surgery with significant result shows less swelling in laser operculectomy than conventional procedure.and Gingival index for laser operculectomy showed provoked bleeding during and immediately after laser surgery it disappeared the day after the treatment (Table 10)
- Gingival index following conventional operculectomy showed spontaneous bleeding during, immediately and one day after the treatment which subsided during one week.(Table 11)
- (Table 12) shows the evaluation of mean Gingival index during the whole period of laser and compare it with conventional surgery with significant result shows less gingival inflamation in laser operculectomy than conventional surgery..
- Most of the patients were satisfied with the laser operculectomy. (Table 13).

Table 1: The percentage and frequency distribution of sample according to age group and gender.

Age	Male (%)	Female (%)	Total (%)
20 and less	1 (10)	0 (0)	1 (10)
21 – 30	2 (20.)	6 (60)	8 (80)
31 and above	0 (0)	1 (10)	1 (10)
Total	3 (30)	7 (70)	10 (100)

Table 2: The percentage and frequency distribution of sample according to the degree of acute episodes.

Frequency of occurance / year	Number of patients (%)
1–4x	3 (30.)
5–8x	7 (70)
9–12x	0 (0)
> 12x	0 (0)
Total	10 (100)

Table 3: The percentage and frequency distribution of sample according to symptoms of peicoronitis.

Symptoms	Number of patients (%)
Pain	10 (100)
Pain–when touched/pressed	8 (80)
Pain–difficulty swallowing liquids and food (e.g., sweet, sour, etc.)	10 (100)
Total	10 (100)

Table 4: The percentage and frequency distribution of sample according to verbal Pain scale during and after the laser treatment.

	0 (%)	1 -3 (%)	4 – 6(%)	7 – 9 (%)	10 (%)	Total (%)	Mean	Std. Deviation
Immediate reaction to treatment	1 (10)	1 (10)	7 (70)	1 (10)	0 (0)	10 (100)	2.20	1.317
Immediately post operative	10 (100)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)	0.00	0.000
One day post operative	1 (10)	7 (70)	2 (20)	0 (0)	0 (0)	10 (100)	1.70	1.252
Two days post operative	7 (70)	2 (20)	1 (10)	0 (0)	0 (0)	10 (100)	0.60	1.265
Three days post operative	7 (70)	3 (30)	0 (0)	0 (0)	0 (0)	10 (100)	0.40	0.699
One week post operative	8 (80)	2 (20)	0 (0)	0 (0)	0 (0)	10 (100)	0.20	0.422
two weeks post operative	10 (100)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)	0.00	0.000

Table 5: The percentage and frequency distribution of sample according to verbal Pain scale during and after the conventional treatment.

	0 (%)	1 -3 (%)	4 – 6(%)	7 – 9 (%)	10 (%)	Total (%)	Mean	Std. Deviation
Immediate reaction to treatment	0 (0)	0 (0)	7 (70)	3 (30)	0 (0)	10 (100)	5.00	1.414
Immediately post operative	0 (0)	1 (10)	2 (20)	7 (70)	0 (0)	10 (100)	6.00	2.261
One day post operative	0 (0)	6 (60)	2 (20)	2 (20)	0 (0)	10 (100)	3.40	2.716
Two days post operative	0 (0)	5 (50)	5 (50)	0 (0)	0 (0)	10 (100)	2.60	1.430
Three days post operative	0 (0)	9 (90)	1 (10)	0 (0)	0 (0)	10 (100)	1.40	.966
One week post operative	10 (100)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)	0.00	0.000
two weeks post operative	10 (100)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)	0.00	0.000

Table 6: Evaluation of mean verbal pain scale during the Periods of Laser versus conventional operculectomy.

	Laser Vs Conventional	0 (%)	1 -3 (%)	4 – 6(%)	7 – 9 (%)	10 (%)	Total (%)	Chi-square test	P value
Immediate reaction to treatment	Laser	1 (10)	1 (10)	7 (70)	1 (10)	0 (0)	10 (100)	16.500[a]	,001
	Conventional	0 (0)	0 (0)	7 (70)	3 (30)	0 (0)	10 (100)		
Immediately post operative	Laser	10 (100)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)	20.000[a]	,000
	Conventional	0 (0)	1 (10)	2 (20)	7 (70)	0 (0)	10 (100)		
One day post operative	Laser	1 (10)	7 (70)	2 (20)	0 (0)	0 (0)	10 (100)	3.619[a]	,306
	Conventional	0 (0)	6 (60)	2 (20)	2 (20)	0 (0)	10 (100)		
Two days post operative	Laser	7 (70)	2 (20)	1 (10)	0 (0)	0 (0)	10 (100)	10.800a	,005
	Conventional	0 (0)	5 (50)	5 (50)	0 (0)	0 (0)	10 (100)		
Three days post operative	Laser	7 (70)	3 (30)	0 (0)	0 (0)	0 (0)	10 (100)	11.000a	,004
	Conventional	0 (0)	9 (90)	1 (10)	0 (0)	0 (0)	10 (100)		
One week post operative	Laser	8 (80)	2 (20)	0 (0)	0 (0)	0 (0)	10 (100)	2.222a	,136
	Conventional	10 (100)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)		
two weeks post operative	Laser	10 (100)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)	Not found	Not found
	Conventional	10 (100)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)		

Table 7: The percentage and frequency distribution of patients according to presence and size of the post operative swelling after Laser treatment.

	No swelling(%)	Papillar(%)	marginal (%)	¾ crown (%)	Total (%)	Mean	Std. Deviation
Immediately post Operative	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	0	0.000
One day post operative	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	0	0.000
Two days post operative	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	0	0.000
Three days post operative	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	0	0.000
One week post operative	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	0	0.000
two weeks post operative	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	0	0.000

Table 8: The percentage and frequency distribution of patients according to presence and size of the post operative swelling after conventional treatment.

	No swelling (%)	papillary(%)	marginal (%)	¾ crown (%)	Total (%)	mean	Std. Deviation
Immediately post operative	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	00	0.000
One day post operative	3 (30)	7(700)	0 (0)	0 (0)	10 (100)	0.7	.483
Two days post operative	4 (40)	6 (60)	0 (0)	0 (0)	10 (100)	0.6	.516
Three days post operative	4 (40)	6 (60)	0 (0)	0 (0)	10 (100)	0.6	.516
One week post operative	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	000	0.000
two weeks post operative	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	00	0.000

Table 9: Evaluation of mean size of swelling during the Periods of Laser versus conventional operculectomy.

	Laser Vs Conventional	No swelling(%)	papillary(%)	marginal (%)	¾ crown (%)	Total (%)	Chi-Square test	P value
Immediately post operative	**Laser**	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	Not found	Not found
	Conventional	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)		
One day post operative	**Laser**	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	10.769a	,001
	Conventional	3 (30)	7(700)	0 (0)	0 (0)	10 (100)		
Two days post operative	**Laser**	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	8.571a	,003
	Conventional	4 (40)	6 (60)	0 (0)	0 (0)	10 (100)		
Three days post operative	**Laser**	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	8.571a	,003
	Conventional	4 (40)	6 (60)	0 (0)	0 (0)	10 (100)		
One week post operative	**Laser**	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	Not found	Not found
	Conventional	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)		
two weeks post operative	**Laser**	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)	Not found	Not found
	Conventional	10 (100)	0 (0)	0 (0)	0 (0)	10 (100)		

No statistics are computed because laser swelling index is a constant in both groups

Table 10: The percentage and frequency distribution of patients according to Gingival Index after Laser operculectomy.

	0 (%)	1 (%)	(%)	Total (%)	Mean	Std. Deviation
Immediate reaction to treatment	0 (0)	0 (0)	10 (100)	10 (100)	2.00	0.000
Immediately post operative	0 (0)	0 (0)	10 (100)	10 (100)	2.00	0.000
One day post operative	0 (0)	10 (100)	0 (0)	10 (100)	1.00	0.000
Two days post operative	0 (0)	10 (100)	0 (0)	10 (100)	1.00	0.000
Three days post operative	0 (0)	10 (100)	0 (0)	10 (100)	1.00	0.000
One week post operative	0 (0)	10 (100)	0 (0)	10 (100)	1.00	0.000
two weeks post operative	0 (0)	10 (100)	0 (0)	10 (100)	1.00	0.000

Table 11: The percentage and frequency distribution of patients according to Gingival Index after conventional operculectomy.

	0 (%)	1 (%)	3 (%)	Total (%)	Mean	Std. Deviation
Immediate reaction to treatment	0 (0)	0 (0)	10 (100)	10 (100)	3.00	0.000
Immediately post operative	0 (0)	0 (0)	10 (100)	10 (100)	3.00	0.000
One day post operative	0 (0)	0 (0)	10 (100)	10 (100)	3.00	0.000
Two days post operative	0 (0)	2 (20)	0 (0)	10 (100)	1.80	0.422
Three days post operative	0 (0)	7 (70)	3 (30)	10 (100)	1.30	0.483
One week post operative	0 (0)	10 (100)	0 (0)	10 (100)	1.30	0.483
two weeks post operative	0 (0)	10 (100)	0 (0)	10 (100)	1.00	0.000

Table 12: Evaluation of mean Gingival Index during the Periods of Laser versus conventional operculectomy.

	Laser Vs Conventional	0 (%)	1 (%)	(%)	Total (%)	Chi-Square test	P value
Immediate reaction to treatment	Laser	0 (0)	0 (0)	10 (100)	10 (100)	Cannot be done	Not found
	Conventional	0 (0)	0 (0)	10 (100)	10 (100)		
Immediately post operative	Laser	0 (0)	0 (0)	10 (100)	10 (100)	Cannot be done	Not found
	Conventional	0 (0)	0 (0)	10 (100)	10 (100)		
One day post operative	Laser	0 (0)	10 (100)	0 (0)	10 (100)	20.000	0,000
	Conventional	0 (0)	0 (0)	10 (100)	10 (100)		
Two days post operative	Laser	0 (0)	10 (100)	0 (0)	10 (100)	Cannot be done	Not found
	Conventional	0 (0)	10 (100)	0 (0)	10 (100)		
Three days post operative	Laser	0 (0)	10 (100)	0 (0)	10 (100)	20.000	0,000
	Conventional	0 (0)	7 (70)	3 (30)	10 (100)		
One week post operative	Laser	0 (0)	10 (100)	0 (0)	10 (100)	Cannot be done	Not found
	Conventional	0 (0)	10 (100)	0 (0)	10 (100)		
two weeks post operative	Laser	0 (0)	10 (100)	0 (0)	10 (100)	Cannot be done	Not found
	Conventional	0 (0)	10 (100)	0 (0)	10 (100)		

No statistics are computed because laser GI is a constant in both groups

Table 13: The percentage and frequency distribution of patients according Patient satisfaction to laser versus conventional treatment.

Method of operculectomy	Number of patients (%)
Laser	8 (80)
Conventional	2 (20)
Total	10 (100)

3.2. Discussion:

The present study is a split mouth clinical trial study. The sample was consisting of 10 subjects, aged 20 years and above divided into three groups according to age. About 8 subjects (80%) of the total sample is between the age of 21 - 30 years (Table1). The females represent (70 %) of the sample while males are (30 %) of the total sample (Table 1).

Table (2) shows the distribution of the sample according to degree of acute episodes. (70%) of Subjects get the acute episodes between 5 to 10 times per year, while (30%) of them get less than 5 times per year.

With regard to the symptoms all subjects were on pain (80%) of them suffered from pain when the area is touched. (10%) suffered from pain and difficulty swallowing (Table 3) this is in agreement of the study of Kay LW. Et al whom assumed the same result [Nelson JS, et. al. (1998)].

. (Table 4) shows that there was mild pain during the laser operculectomy which disappeared immediately after the procedure was done, mild pain started the second day which subsided and disappeared within two weeks . Table (5) shows that there was moderate pain after the laser operculectomy which started to increase in the second day then subsided and disappeared within one week.

In the present study, as shown in (table 6): the mean pain scale was seen less after laser operculectomy than in conventional surgery this is in consistence with the result of Sarver DM et al (Kreisler M. (2005)) (2005) who assumed that due to Apart from conventional mechanical debridement and operculectomy with scalpel, electrosurgery has been utilized effectively to excise gingival tissue while simultaneously providing adequate hemostasis.(*Covina, Calif. (2007)*) Heat generation with this technique, however, occurs to a degree where an irreversible damage to the alveolar crest may result.(*Schuocker, D. (1998).*)

Table (7), the swelling following laser operculectomy was not seen in the present study while little is seen the one day following conventional operculectomyand disappears within one week (Table 8) this is in consistence with that of Sarver DM (Kreisler M. (2005)),

-Table (9) shows a significant result (p value = 000) in comparison of swelling after laser versus conventional surgery, it is shown that there was no marked swelling after laser surgery unlike conventional this is seems because diode laser have an excellent incision performance with a cutting depth of 2 to 6 mm with and have an added advantage over conventional surgery in that there is sealing of small blood and lymphatic vessels resulting in hemostasis and reduced post operative edema[Kreisler M.(2005)]. ("laser". Reference.com.(2008)) (, Paul Hewitt, (2002)).

-(Tables 10, 11 and 12) in the present study shows result similar to CO_2 laser result which is done by Levine et al (*Siegman. (1986).*), and suggested to be due to the photo-thermal ablation device and excellent coagulation because of the close match between its coagulation depth and the diameter of oral soft-tissue capillaries (*Siegman,(1986)*).

In this study the patients were satisfied from laser operculectomy more than conventional surgery (table 13), this is in consistence with Levine et al (*Siegman,(1986*.) and it is due to the painless procedure with less no complications.

- It is very difficult to elaborate a hypothesis on why subjects with a laser operculectomy are found in increased frequency in less pain, less swelling, and less post operative gingivitis. However, the occurrence of these are the result of many factors and the probable genetic influence demonstrates a small facet of multifactorial etiology of this disease. Since most of these studies are carried out on a small group of subjects, until universal figures based on longitudinal studies are made available, the decision as to whether a particular laser surgery group has a particular or conventional should be put off. Until then, all reports of preponderances should be accepted on the basis of their backgrounds and shortcomings and be interpreted cautiously.

CHAPTER FOUR

Conclusion
and
Recommendations

- Conclusion and Recommendations

4-1- - Conclusion:

- Pain and discomfort in laser operculectomy is less than that in conventional surgery.

- There is no marked swelling around the tooth when operculectomy is done by laser.

- The area of surgery shows less inflammation and less healing duration when operculectomy is done by laser than by conventional surgery.

-The diode laser does not influence structural tooth surface characteristics adversely, regardless of power utilized.

- Limitation of using laser to remove the operculum relate primarily to the soft tissue anatomy of the area around and above the tooth and the tooth position .

-Reducing the attached gingiva would limit the use of the laser due to the elimination of the soft tissue.

4-2- : **Recommendation.**

- Soft tissue lasers should be recommended as the best alternative methods for the conventional blade and suture techniques, If no other periodontal surgical procedures are required at the same time.
- Future studies should be done to compare using laser to uncover dental implants versus conventional surgical procedueres.

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بسم الله الرحمن الرحيم

السيد::_______________________________________

المحترم

السلام عليكم ورحمة الله وبركاته

الموضوع : بحث عن المقارنة بين استخدام الليزر مع الجراحة التقليدية في استئصال اللثة الزائدة جول ضرس العقل السفلي

في اطار البحوث العلمية التي نجريها حول امراض الاسنان المختلفة وسعياً منا في ايجاد الحلول المناسبة نرجو منكم تعاونكم معنا في اجراء الدراسة اعلاه والتي تشمل عمل علاج سني لايتعدى الربع ساعة مع المتابعة وبعض الاسئلة المصاحبة.

ولكم جزيل الشكر والتقدير

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