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HEMORRHOIDS TREATMENT USING CO_2 LASER (10600NM)

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ABSTRACT

Background*:** Hemorrhoids is a common surgical condition that affects 10% of population at some time in their life, different modalities of treatment have been used throughout years, one of the methods is using co_2 laser. laser is an effective, simple and harmless clinical procedure used for the treatment of hemorrhoids, as an alternative to medical therapy or other surgical therapy. ***Objective*:** This study was undertaken to evaluate efficacy and safety of hemorrhoidectomy using CO_2 laser. ***Patients and methods: This study was done in the laser medicine research clinic / institute of laser for postgraduate studies and Al-Banook private hospital from early July 2O15 to the end of November 2015, twenty five patients were enrolled in this study,20 Male and 5 Female, their ages ranged from 18 - 60 years old with a mean of 38.25 years old. 15 patients (60%) had 4th degree hemorrhoid while 10 patients (4O%) had third degree hemorrhoid. The Laser parameters used were CO_2 laser wavelength 10600nm, continuous wave, Power 5-10 watt, spot size of the hand piece was 0.4mm. Laser hernorrhoidectomy was performed under local, spinal, general anesthesia. ***Results*:** All patients had a single session, the operative time ranged from 15 – 20 minutes; the mean 17 minute. 15 patients(60%)were completely satisfied 5 patients (20%) were greatly but not fully satisfied.3 patients (12%) were partially satisfied,2 patients (8%) was not satisfied,4 patients (16%) had no pain, 18 patients (72%) had mild pain,3 patients (12%) had severe pain 21 patients (84%) had no bleeding, (12%) 3 patients had early simple bleeding, (4%) one patients had bleeding after two weeks. 2 patients (8%) developed simple wound infection, 23 patients (92%) had no infection. 4% one patient suffered from urine retention catheter put. 3 patients (12%) developed mild anal stenosis. Only one patients (4 %) had recurrence All of the patients were discharged after 3-5 hour and none required hospital stay and they returned to work after one week. ***Conclusion*:** Co_2 laser hemorrhoidectomy is effective and safe procedure, an uneventful postoperative course, no hospitalization and quicker return to work.

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INTRODUCTION

Hemorrhoids are one of the common surgical conditions. At least 10% of the population will have symptomatic hemorrhoids at some time in their life. Different modalities of treatment have been used throughout years, one of the alternatives to medical and surgery was using CO_2 laser [(1)].

Aim of the study: The purpose of this study was to evaluate the efficacy and the safety of CO_2 laser (10600nm) in treatment of third and fourth grades of hemorrhoids.

PATIENTS AND METHODS

This study was done in the laser medicine research clinic / institute of laser for postgraduate studies and Al-Banook private hospital from early July 2O15 to the end of November 2015, twenty five patients were enrolled in this study,20 Male and 5 Female, their ages ranged from 18 - 60 years old with a mean of 38.25 years old. 15 patients (60%) had 4th degree hemorrhoid while 10 patients (4O%) had third degree hemorrhoid. The Laser parameters used were CO_2 laser wavelength 10600nm, continuous wave, Power 5-10 watt, spot size of the hand piece was 0.4mm. Laser hernorrhoidectomy was performed under local, spinal, general anesthesia.

RESULTS

All patients had a single session, the operative time ranged from 15–20 minutes; the mean 17 minute. 15 patients (60%) were completely satisfied 5 patients (20%) were greatly but not fully satisfied. 3 patients (12%) were partially satisfied, 2 patients (8%) was not satisfied, 4 patients (16%) had no pain,

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DISCUSSION

Anatomy of the anus: The anal canal commences at the level where the rectum passes through the pelvic diaphragm and ends at the anal verge. The internal sphincter is composed of circular, non striated involuntary muscles supplied by autonomic nerves. The external sphincter is composed of striated voluntary muscle supplied by the pudendal nerve. [(2)] Extensions from the longitudinal muscle layer support the sphincter complex. The space between sphincters is known as the intersphincteric plane. The superior part of the external sphincter fuses with the puborectalis muscle, which is essential for maintaining the anorectal angle, necessary for continence.[(2)] The lower part of the anal canal is lined by sensitive squamous epithelium. Blood supply to the anal canal is via superior, middle and inferior rectal vessels. Lymphatic drainage of the lower half of the anal canal goes to the inguinal lymph nodes.[(2)]

Definition and Grades of Hemorrhoids: A hemorrhoid is an enlarged veins within the anal canal, which has become swollen or inflamed due to an increase in pressure in the vein, many hemorrhoid sufferers experience pain, bleeding, tissue prolapsed (bulging)through the rectum and anal discharge.[(3)] There are two types of hemorrhoids - Internal and external. lnternal hemorrhoids occur higher up in the anal canal, out of sight. Bleeding is the most common symptom of internal hemorrhoids. -External hemorrhoids are visible-occurring out side the anus. They are basically skin-covered veins that have ballooned and appear blue. Usually they appear without any symptoms. When inflamed, however, they become red and tender. lnternal hemorrhoids occur inside the anus. The swollen blood veins remain inside the anus and do not usually cause pain. The size of internal hemorrhoids are classified using a grading system from 1 to 4.[(3)]

Grade 1- hemorrhoids are often small swellings inside the lining of the anus. They cannot be seen and are very common. ln some cases they will enlarge to grade 2 hemorrhoids.[(4)]

Grade 2- hemorrhoids are larger in size but are still within the anus. ln some instances they become pushed out when pass stool, but will return inside spontaneously after.[(4)] Grade 3- hemorrhoids appear outside the anus. These are also referred to as prolapsed hemorrhoids. ln most cases these hemorrhoids can be pushed back inside the anus.[(4)] Grade 4- hemorrhoids remain outside the anus permanently. They cannot be pushed back inside and will need to be treated by a doctor.[(4)]

Causes of hemorrhoids: Swollen veins - hemorrhoids - can develop from an increase in pressure in the lower rectum. Factors that might cause increased pressure include:

1. Straining during bowel motion
2. Sitting for long periods of time on the toilet
3. Chronic diarrhea or constipation
4. Obesity
5. Pregnancy
6. Lax sphincter

It's also possible to inherit a tendency to develop hemorrhoids. Hemorrhoids are more likely when getting older because the tissues that support the rectal veins get weak and stretch with aging. [(5)]

Conventional Treatment options

The best way to prevent hemorrhoids is to keep stools soft so they pass easily, thus decreasing pressure, and to empty bowels without undue straining as soon as possible after the urge occurs. Exercise, including walking, and eating a high fiber diet, help reduce constipation and straining by producing stools that are softer and easier to pass. Major surgery for hemorrhoids can generally be avoided in favor of more sophisticated and often painless methods of treatment. Non-surgical methods of treatment are available to most patients as a viable alternative to a permanent hemorrhoid cure. [(6)]

Bipolar Coagulation: Bipolar electrotherapy is applied for a directed coagulation effect of the mucous membrane near the hemorrhoid. Specialized Bipolar Circumactive Probes (BICAP) are effective for the treatment of bleeding internal hemorrhoids. [(6)]

HAL: Hemorrhoidal Arterial Ligation (H.A.L.) is performed using a modified proctoscope in conjunction with a Doppler ultrasound flowmeter. A needle and thread is passed beneath the artery, and a knot is externally tied, to stop the blood flow to the hemorrhoid. [(6)]

Hemorrhoidolysis: Therapeutic galvanic waves applied directly to the hemorrhoid, produces a chemical reaction that shrinks and dissolves hemorrhoidal tissue. This technique is most effective when it is used on internal hemorrhoids. Therapeutic galvanic waves applied directly to the hemorrhoid, produces a chemical reaction that shrinks and dissolves hemorrhoidal tissue. [(6)]

Injection: To shrink the hemorrhoid and its blood vessels, medicine is injected into the mucous membrane near the hemorrhoid. This method is reserved smallest internal hemorrhoids.[(6)]

Photocoagulation: A device called a photocoagulator focuses infrared light into a fine point at the end of a probe, which spotwelds the hemorrhoid in place. This is used for hemorrhoids that are activety bleeding. [(6)]

Rubber Banding: A special instrument fits a small rubber band over part of the hemorrhoid. A tight rubber band stops the blood flow into the pinched-off portion, which falls off in about a week. This technique is widely used for hemorrhoids protruding into the anal canal. Rubber band ligation can be performed in a doctor's office and requires little preparation. [(6)]

Super Freezing: A cryogenic device uses liquid nitrogen to super freeze the hemorrhoid. This causes the affected tissue to slough off, so that new healthy tissue can grow in its place. This technique is most effective when it is used on external hemorrhoids. [(6)]

Traditional Surgery: Hemorrhoids especially internal hemorroids can be treated by dietary modifications, topical medications and soaking in warm water, which temporarily reduce symptoms of pain and swelling. Additionally, painless non-surgical methods of treatment are available to most of our patients as a viable alternative to a permanent hemorrhoid cure. [6]

1-Milligan-Morgan Technique: Developed in the United Kingdom by Drs. Milligan and Morgan, in 1937. The three major hemorrhoidal vessels are excised. ln order to avoid stenosis, three pear-shaped incisions are left open, separated by bridges of skin and mucosa. This technique is the most popular method, and is considered the gold standard by which most other surgical hemorrhoidectomy techniques are compared. [6]

2-Ferguson Technique: Developed in the United States by Dr. Ferguson, in 1952. This is a modification of the Milligan-Morgan technique (above), whereby the incisions are totally or partially closed with absorbable running suture. A retractor is used to expose the hemorrhoidal tissue, which is then removed surgically. The remaining tissue is either sutured or is sealed through the coagulation effects of a surgical device. [6] Due to the high rate of suture breakage at bowel movement, the Ferguson technique brings no advantages in terms of wound healing (5-6 weeks), pain, or postoperative morbidity. Conventional haemorrhoidectomy can be performed as a day-case procedure. But due to poor post-operative care in the community and high level of pain experienced after the procedure, an in-patient stay is often required.[6] (about one day in Iraq).

Stapled Hemorrhoidopexy (PPH Procedure): Also known as Procedure for prolapse and Hemorrhoids (PPH), stapled Hemorrhoidectomy, and Circumferential Mucosectomy. [6] PPH is a technique developed in the early 90's that reduces the prolapse of hemorrhoidal tissue by excising a band of the prolapsed anal mucosa membrane with the use of a circular stapling device.[7]

The Purse-string Suture Anoscope is then introduced through the dilator" The Hemorrhoidal Circular Stapler is opened to its maximum position. lts head is introduced and positioned proximal to the purse-string, which is then tied with a closing knot [8]. Firing the stapler releases a double staggered row of titanium staples through the tissue. A circular knife excises the redundant tissue, then a circumferential column of mucosa is removed from the upper anal canal [9].

Harmonic Scalpel: The Harmonic Scalpel uses ultrasonic technology, the unique energy form that allows both cutting and coagulation of hemorrhoidal tissue at the precise point of application, resulting in minimal lateral thermal tissue damage. Because the Harmonic Scalpel uses ultrasound, there is less smoke than is generated by both lasers and electrosurgical instruments. [10] By contrast, electrosurgery coagulates by burning (obliterative coagulation) at temperatures higher than 150eC. Blood and tissue are desiccated and oxidized (charred), forming eschar that covers and seals the bleeding area.[11]

Applied to Tissue Hemorrhoidedomy

Atomizing Hemorrhoids: A new technique to remove hemorrhoids is called atomizing. The term "atomizing hemorrhoids" was coined because the hemorrhoids are actually reduced to minute particles into a fine mist or spray, which is immediately vacuumed away. An innovative waveform of electrical current and a specialized electrical probe, the Atomizer Wand", was created for this purpose.[6] The results of atomizing hemorrhoids are similar to that of lasering hemorrhoids, except that there is less bleeding using the Atomizer, and the Atomizer cost less. ln both procedures, it is noted that there is less discomfort, less medication, less constipation, less urinary retention, and a hospital stay is generally not required. Complications using the Atomizer are rare, and excellent results are typical. [12]

Complications of hemorrhoidectomy

Early complications lnclude

1) Severe postoperative pain, lasting 2-3 weeks.
2) Wound infections are uncommon after hemorrhoid surgery. Abscess occurs in less than 1% of cases. Severe necrotizing infections are rare.
3) Postoperative bleeding.
4) Swelling of the skin bridges.
5) Major short-term incontinence.
6) Difficult urination. Possibly secondary to urinary retention, urinary tract infection develops in approximately 5% of patients after anorectal surgery [6].

Late Complications (after 2-3 weeks) include

1) Anal stenosis.
2) Formation of skin tags.
3) Recurrence.
4) Anal fissure.
5) Minor incontinence.
6) Fecal impaction after a hemorrhoidectomy is associated with postoperative pain and narcotic use 7) Delay bleeding [7]

Laser Basics: The term laser is an acronym for light amplification by stimulated emission of radiation. ln 1917, Einstein introduced the concept of stimulated light emission. The first laser was developed by Maiman in 1959 using a ruby crystal to produce red light with 694 nm wavelengths. ln 1963, Dr.Leon Goldman pioneered the use of laser for cutaneous application by promoting ruby laser treatment for a variety of cutaneous pathology. The development of argon laser, Nd: YAG Iaser and carbon dioxide (CO_2) Iaser soon followed and served as the focus of cutaneous laser research during the next two decades. Dr. Parrish revolutionized cutaneous laser surgery in 1980s with the introduction of the theory of selective photothermolysis. [13] For decades many surgical procedures have been done using traditional instruments but can now be performed with lasers that offer significant advantages to the patient: such as less bleeding or no bleeding at all ("bloodless surgery "), no scarring, much greater speed of treatment, much less pain of treatment so that little if any anesthesia required less postoperative swelling, and faster healing and recovery [14]. Lasers are one of the most significant technological developments of the twentieth century lasers are tools that produce a pure and intense form of light that occurs naturally nowhere in the universe. The special properties of lasers have been used to great advantage in medicine and surgery. Many modern surgical procedures would be impossible without laser instrumentation. Surgical lasers produce specific effects that enable precise targeting of

abnormal or unwanted tissue while sparing the "good" tissue [15].

Pulsed and continues wave laser: A continuous wave (CW) laser may be differentiated from pulsed laser, which provides bursts of energy. ln the CW mode, the Laser delivers a continuous beam of light with little or no variation in power output over time ln cw operation, laser output is controlled by the physician, typically by depressing a foot pedal [16]. A pulsed laser delivers its energy in the form of a single pulse or train of pulses. The frequency or pulse repetition rate is the number of pulses emitted in 1s (Hertz) [16]. The duration of the pulse width is defined as the total time required for the pulse to rise from zero intensity. increase to a maximum and then return to zero intensity an alternative definition for pulse width (used for short pulses) is the time between the 50% points on the pulse curve. this is called full width at half maximum super pulse is a term specific to some carbon dioxide laser is that have been modified to produce very short pulse with high peak powers in a repetitive fashion commonly several hundred pulses per second from the physicians point of view. super pulse is most useful for incisional surgery with a focused beam. high peak power maximize tissue vaporization and short pulse duration minimize adjacent thermal injury. [17]

Laser delivery System: Transmission of laser cavity to the tissue is provided by one of three deviced articulated arms optical fibers or micromanipulators [16] Articulated arms direct laser energy from the laser cavity to the desired location through a series of hollow rigid tubes with reflective of the laser wavelength being transmitted so that coherence and power are maintained allowing the fine focusing of the exiting beam a hand piece at the end of the arm contains a lens that focuses the beam. [16] Several limitation remain in articulated arm systems despite recent advances to improve their mobility articulated arms are somewhat cumbersome to use in a clinical setting. the mirrors are easily misaligned when either the laser device or the articulated arm is disturbed. despite the aforementioned limitation carbon dioxide or Er. YAG lasers almost exclusively utitize articulated arms because their infrared wavelength are not transmissible along currently available optical fibers [16] Both articulated arms and optical fibers can be coupled through a microscope with a micromanipulator which provides a controlled means of moving the laser beam across the surface of human skin. the micromanipulator can also be coupled with a computer for completely preprogrammed and precise skin irradiation. [18]

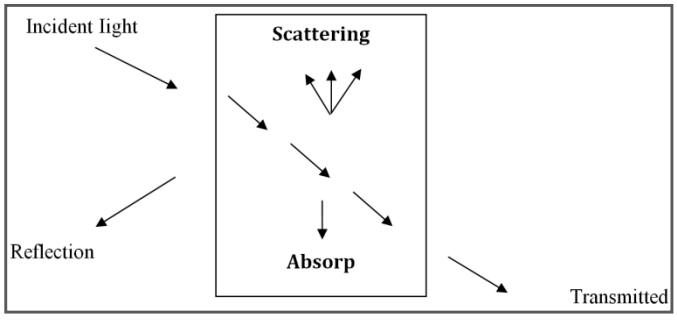

Figure (1.4.1). Reflection, when it strikes a tissue scattering, absorption & transmission of laser light when it strikes a tissue

Laser tissue interaction mechanism: The interaction of laser light with a biological tissue depends mainly on the optical properties of the tissue as well as properties of the laser light. When laser light is incident on a tissue, a part of it is reflected at the surface of the tissue; the remaining part of the laser beam penetrates into the tissue and propagates. While propagation, a part of it is absorbed and a part is scattered by the tissue. For a tissue of finite thickness, some part of the radiation is transmitted.

Mechanism of Laser action in tissues

- Photo thermal
- Photo chemical
- Photo ablation
- Plasma – induced ablation
- Photo disruption

Absorption of laser light: During absorption, the intensity of an incident electromagnetic wave is attenuated in passing through a medium. The absorbance a medium is defined as the ratio of absorbed and incident intensities. 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 temperature and concenilation of absorbing agents [20].

The two laws of either thickness or concentration on absorption respectively.

They are called Lamberts law and Beers law.

l(z)=10 ex'-az
l(z)=10 exP-kcz

where z is the optical axis, l(z) is the intensity at a distance z, l0 is the incident intensity, a is the absorption coefficient of the medium, c is the concentration of the absorbing agents and k depends on internal parameters [21]. The inverse of the absorption coefficient a is referred to as absorption length or penetration depth(z). In biological tissues and Iiving cells, absorptions mainly caused by certain chromospheres (photosensitizes), present naturally in the living cells, for example, absorption in the infrared region of the spectrum can be primarily attributed to water molecules. Proteins as well as pigments absorb the ultraviolet and visible range of the spectrum. The selective interaction between laser radiation and tissues may be obtained by means of endogenous chromospheres', like hemoglobin and melanin for example. And also by means of exogenous chromospheres like certain dye The absorbed portion of the laser radiation can produce wavelength dependent and wavelength independent interaction mechanisms, [22].

Photo thermal interaction: In this interaction, absorption of photons energy within the rotational and vibration levels leads to increase the kinetic energy and collision between the atoms and molecules, so increase in local temperature is the significant parameter change. Heat generation is determined b y laser parameters and optical tissue properties, primarily, irradiance, exposure time and the absorption coefficient. According to the tissue temperature achieved, different effects like coagulation, vaporization, carbonization and melting may be distinguished. [23]

Photochemical interactions: Photo excite molecules or atoms, making the molecules more likely to undergo chemical

reactions with other molecules. Applications include Photodynamic therapy, and Biostimolation [24].

Table (1.4). Thermal effect of laser radiation

Temperature	Biological effect
37° c	Normal
45° c	Hyperthermia
50° c	Reduction in enzyme activity, cell immobility
60° c	Denaturation of proteins and collagen, coagulation
80° c	Increase Permeabilization of membranes
100° c	Vaporization, thermal decomposition
>150° c	Carbonization
>300° c	Melting

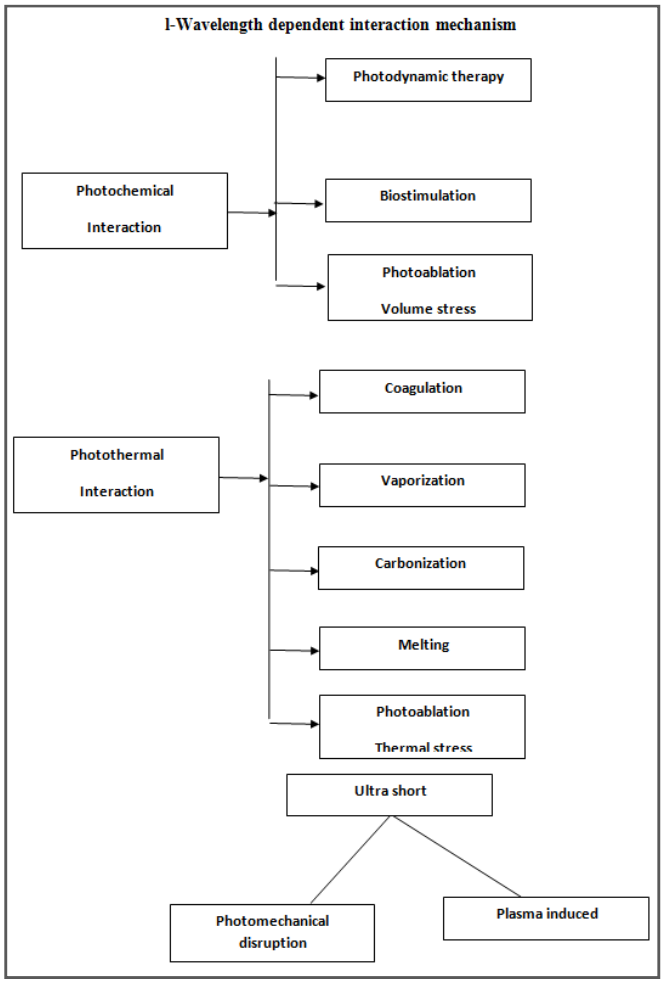

Fig (1.4.2). Wavelength dependent and wavelength independent interaction mechanisms

2-Wavelength independent interaction mechanisms

A-Photo ablation

The energetic photons of the laser light decompose the molecules by breaking the bonds at the impart excess energy for ejection. ln this interaction, photo ablation is due to volume stress as a result of bond breaking. In photo thermal interaction, photo ablation is due to thermal stress as a result of absorption of high intensity laser light photons.[25]

B-Photodisruption:

- Main idea fragmentation and cutting of tissue by mechanical forces
- Observations plasma sparking generation of shock waves, cavitation, iet Formation
- Typ. Lasers solid-state lasers, e.g. Nd:YAG, Nd:YLF, Ti:Sapphire
- Typ. pulse durations 100 ns - 100 fs
- Typ. power densities 10^{11} - 10^{16} W/cm^2
- Special applications (minimally invasive surgery), lens fragmentation, Lithotripsy.

C - Plasma-induced ablation

- ❖ It is a very clean and well-defined removal of tissue by optical breakdown without evidence of thermal or mechanical damage (i.e. this kind of ablation is primarily caused by plasma ionization) which can be achieved when choosing appropriate laser parameters (i.e. High local power density and very short laser pulses).
- ❖ It was recently investigated and discussed by Teng et al. (1987), Stern et al (1989), and Niemz et al. (1991).[15]

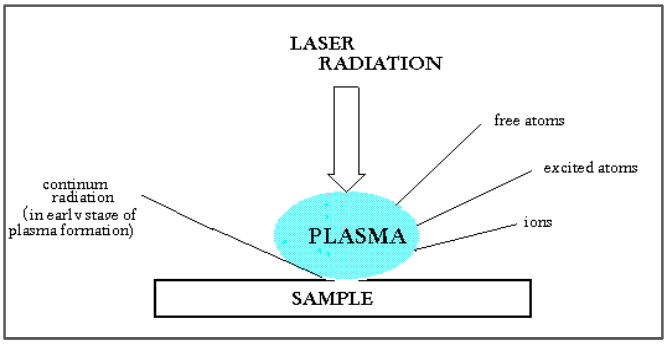

Figure (1.4.3). Plasma induced ablation

Typical lasers parameters for plasma induced ablation:

- ➢ Laser types: Nd:YAG, Nd:YLF, Ti:Sapphire
- ➢ Pulse durations: 500 ps – 100 fs
- ➢ Power densities:10^{11} – 10^{13} W/cm^2
- ➢ Special applications: Refractive corneal surgery, caries therapy.

Very short laser pulses (ps, fs) remove material so quickly that the surrounding material absorbs very little heat, Although there is intense heat at the point of plasma formation, the spot is so small that the heat dissipates rapidly. So laser ablation and drilling can be done on delicate or heat-sensitive tissues, including tooth caries (laser dentistry). [15] When obtaining power densities exceeding (10^{11} W/cm^2 in solids and fluids) or (10^{1} W/cm^2 in air) - a phenomenon called optical breakdown or dielectric breakdown occurs and this lead to plasma generation. [26] The term optical breakdown (i.e. where the wavelength of incident laser beam is not important in the interaction- ג independ regime) emphasizes that UV, visible, and IR light are strongly absorbed by the plasma. [27]

Laser fundamentals (Properties)

The word Laser is an acronym for light amplification by stimulated emission of radiation (Light Amplification by Stimulated Emission of Radiation).

What is Laser? Laser is a concentrated narrow beam of coherent, collimated, monochromatic light with a high energy travelling in a particular direction (unidirectional).

- Laser is a light with special properties
- These properties include :-

  - ❖ Coherent : all waves are in phase, synchronized
  - ❖ Collimated : parallel, no divergence, very narrow beam
  - ❖ Monochromatic : single color, single wavelength
  - ❖ Unidirectional : one direction
  - ❖ Highly focused : concentrated with pinpoint accuracy
  - ❖ Brightness : extremely high-intensity (high energy)

These unique characteristics make the laser useful for thousands of applications including medical applications. [28]

Types or classification of laser

Many classification :

1- According to active medium
(Gas, solid, or a semi – conductor)

2- According to power
(Low power, Intermediate power, high power)

3- According to wavelength
(Ultraviolet, visible, or infrared)

4- According to output (Nature of emission)
(Continuous wave, pulsed wave laser)

5- ACCORDING TO LASER TECHNIQUE
(Contact and non-contact)[29]

Common components (elements) of all laser

All laser, regardless of size, shape, style, or application, have three main components:

1-Active Medium: The active medium is a collection of atoms, molecules or ions that absorb energy source and generate laser Iight by stimulated ernission from an outside. active medium can consist of a solid, liquid, gas or a semiconductor material.

2-Excitation Mechanism: Excitation mechanisms pump energy into the active medium by one or more of three basic methods; optical, electrical or chemical. [30]

1- Optical Resonator: Reflect the laser beam through the active medium for amplification. it is consist of :

   - High Reflectance Mirror: A mirror which reflects 100% of the laser light.
   - Partially Transmissive Mirror: A mirror which reflects less than 100% of the laser light and transmits the remainder (The output coupler)[31].

Revised (new) Laser Hazard Classification: The American National Standards Institute (ANSI) has established lnstitute (ANSI) has established a revised (new) laser hazard classification system in publication ANSI Z136. 1-2007 The following is a summary of this laser hazard classification system:

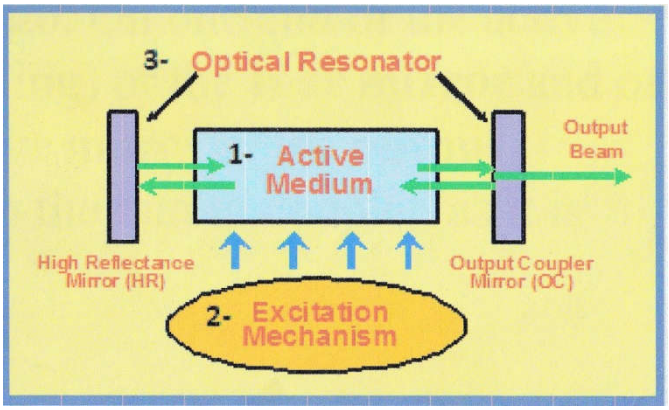

Figure (1.4.4). Laser Components

Class 1

Very low powered lasers (< 0.4 microwatts)
Incapable of producing eye injury.

A Class 1 laser or laser system can be used without restriction in the manner intended by the manufacturer and without special operator training, qualification (Exempt from any control measures or other forms of surveillance).

Examples:

- Laser printers / CD players

Class 1 M (NEW!)

Incapable of producing eye injury unless optics (focusing device such as : a lens or telescope) are used for viewing. Exempt from any control measures other than to prevent potentially hazardous optically aided viewing ; and also is exempt from other forms of surveillance [32].

Class 2:

- ❖ Emits in the visible part of the spectrum
- ❖ Low power laser > 0.4 u W but < 1 m W
- ❖ No eye damage is likely, because the eye is protected by the blink reflex.

i.e: The laser does not have enough output power to injure a person accidentally, but may injure the eye when stared at for a long period.

- ❖ A caution label is required.

Class 2M (NEW !):

- ❖ Emits in the visible part of the spectrum.
- ❖ Less than 1 m W
- ❖ No eye damage is likely but it is potentially hazardous

If viewed with certain optical aids (lends or telescope).

Examples:

- Low power HeNe laser, especially in school labs
- Classroom demonstration pointer
- Aiming device
- Bar Code scanners
- Range finder [33]

Class 3 laser system (medium – power):

May be hazardous under direct and specular reflection viewing conditions, but is normally not a diffuse reflection or fire hazard. There are two subclasses:

Class 3R (Class 3A)

- Power from 1 mW to 5 mW
- Eye damage may occur if the beam is viewed directly or by specular reflection and the eyes are stable.
- A caution sign must label the device.

Examples:

- Many red laser pointers
- Some HeNe lab laser

Class 3B

- Power from 5 mW to 500 mW
- Eye damage may occur for direct viewing or viewing of specular reflections.
- Not a diffuse reflection hazard or a fire hazard.
- A danger sign must label the device.
- Eye protection is required. [34]

Class 4 (high – power)

- High Power Laser and Laser Systems (above 500 mW)
- Eye and skin damage will occur for direct viewing or viewing of specular or diffuse reflection of the beam.
- Potential fire hazard.
- May produce laser generated air contaminants (LGAC) or plasma radiation.
- A danger sign will label this laser.
- Eye and skin protection are required.

Examples:

- CO_2 Laser
- Nd:YAG (532 nm) as Q-switched
- Ti:Sapphire oscillator
- Argon ion laser [35]

Types of Laser Hazards: The hazards of lasers may be separated into two general categories:

I) RADIATING (BEAM) HAZARDS:

1. Eye hazard
2. Skin hazard

ll) NON- RADIATING (NON-BEAM) HAZARDS:

1. Fire hazard
2. electrical hazard
3. Chemical hazard
4. Explosion hazard
5. Laser generated air contaminants (LGAC)
6. Collateral and Plasma Radiation
7. Other hazards [36]

Lasers beam damage mechanisms: Lasers can cause damage in biological tissues, both to the eye and to the skin, due to several mechanisms.

- Thermal damage, or burn, occurs when tissues are heated to the point where denaturation of proteins occurs. Most of the infrared light is absorbed by melanin pigments in the pigment-epithelium and causes burns in the retina.
- Another mechanism is Photochemical damage where light triggers chemical reactions in tissue). Photochemical damage occurs mostly with short-wavelength (blue) and Ultraviolet light. Ultraviolet light with wavelengths shorter than 400 nm tends to be absorbed in the cornea and lens, where it can produce injuries at relatively low powers due to photochemical damage
- Acoustic shock (Photo disruption) from exposure to high energy pulsed lasers results in physical tissue damage[37].

General view on CO2 Laser

- Carbon dioxide Laser: This laser distroys tissues by vaporising cells. Tissue which contains 8O%-9O% water, when exposed to the laser, is destroyed by steam formation within the cell. The destroyed area is localised and shows no combustion since the intracellular temperatures never exceed 100^{o} C. There is minimal damage to the surrounding areas.[38]
- Carbon dioxide laser is extensively used in surgery. Lasers have now become the preferred surgical instruments for many diseases of the nose, oral cavity, trachea, larynx and pharynx. lt is used in the treatment of cervical and vaginal neoplasia.[39]
- The carbon dioxide laser (co_2 laser) was one of the earliest gas lasers to be developed (invented by Kumar Patel of Bell Labs in 1964), and is still one of the most useful. carbon dioxide lasers are the highest-power continuous wave lasers that are currently available. They are also quite efficient: the ratio of output power to pump power can be as large as20%. [40]The CO_2. laser produces a beam of infrared light with the principal wavelength bands centering around 9.4 and 10.6 micrometers. [41]

Laser application in hemorrhoids

- Skilled surgeons use laser light with pinpoint accuracy. The hemorrhoid is simply vaporized or excised. The infinitely small laser beam allows for unequaled precision and accuracy, and usually rapid, unimpaired
- healing. The result is less discomfort, less medication, and faster healing. The laser is inherently therapeutic, sealing off nerves and tiny blood vessels with an invisible light. By sealing superficial nerve endings patients have a minimum of postoperative discomfort. With the closing of tiny blood vessels, your proctologist is able to operate in a controlled and bloodless environment. Laser can be use alone or in combination with other modalities.[42]
- There are several types of laser system for hemorrhoidecty :
- CO_2 laser (cutting-edge technology) is transmitted by mirrors and cannot go through fluids. lts use is superficial and it cuts in a very precise, clean way, but it has rather low coagulation ability.
- The Neodymium/YAG laser coagulates well but the cut is rather poor. It goes deep into the tissue and tends to

burn it. lt goes through the fluids, being transmitted by optic fiber.
- Mild postoperative pain
- No damage of the sphincter as long as careful dissecting the mucosa from the underlying sphincter
- No stenosis
- Combination with or change for other procedure possible
- Faster healing as there is no incision or stitches
- Several repetitions possible [43]

Disadvantages of using laser treatment of hemorrhoids: hemorrhoids laser treatment cost is high as the equipment is expensive and is not used in many other procedures or specialties that can defer the cost, also need training and experience.

Contraindications to CO_2 Laser therapy:

- Impaired wound healing in debilitating disease.
- Recent treatment with isotretenoin, steroid and anticoagulants only in laser skin treatment e.g : face
- Active herpes, warts or bacterial infection within the area to be treated [28]

Conclusion:

Co_2 laser hemorrhoidectomy is effective and safe procedure, an uneventful postoperative course, no hospitalization and quicker return to work.

List of abbreviations:-
CO2 Carbon dioxide laser
Nd:Yag Neodymium: yattrium aluminum granatte laser
Er: Yag Erbium: yatrium aluminum granatte laser
KTP potassium Titanyl phosphate
J Joule
IEC lnternational electro technicalcommission
ANSI American nationalstandard institute
AEL Accessible emission limits
lR lnfrared
uv Ultaviolet
CW Continuous wave
GW Gigawatts
CPG Computerized pattern generator
HAL Hemorrhoidal Arterial Ligation
HAI-RAR Hemorroid Artery Ligation - Recto-anal Repair proctoplasty
A.M.l Agency for Medical tnnovations
(DGl RAR Doppler Guided Recto Anal Repair Proctoptasty
(DG) HAL Doppler Guided HemorrhoidalArtery Ligation
PPH procedure for prolapse and Hemorrhoids
EMLA Eutectic mixture local anesthetic
BICAP Bipolar Circumactive probes
PS Picosecond
FS Femtosecond
CM Centimeter

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