

Studying The Interaction of Laser with Human Tissue

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Abstract: A laser is amplified light beam to emit radiation. these rays are used in surgery by accurately projecting laser light to remove diseased tissue or bleed blood vessels by heating the target cells until they explode. The laser is used medically under objective or complete anesthesia. There are many types of lasers such as carbon dioxide laser, YAG laser, and argon beam, and each type of laser has a specific use, and each type of surgery and tissue has a special color of laser light. the uses of the laser in the surgery are multiple. brain and liver tumors can be removed while not to damage the healthy tissue surrounding the tumors. Lymphatic vessels can be closed to reduce the spread of tumor cells and nerve endings to reduce pain after surgery, small bleeding blood vessels can be closed, in addition to removing warts and skin tumors. A general advantage of laser surgery is the absence of bleeding, reduced surgical infections, pain and wound size, and a short hospital stay. The recovery period after laser treatment depends on the type of pathological condition and the patient's health condition before treatment. In the end: the laser has successful surgical uses to obtain good results with minimal complications, and contrary to what is common, its medical uses are specific to certain diseases and not for all types of surgery. In addition, laser treatment requires modern and complex devices and experienced experts in their use.

Keywords: laser, YAG laser, Lymphatic vessels.



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Introduction

The invention of the laser is considered one of the most exciting inventions of this era, as no one would have thought that this simple light source would open countless doors of extremely important applications in human life. Scientists wondered among themselves after the manufacture of the first laser in 1960 A.D. about What will be the applications of this wondrous device, as the motive behind the intensive research that led to the invention of the laser was to satisfy the curiosity of scientists not only, in contrast to many inventions, which were the need behind their invention. But after a few years, scientists in various disciplines caught this wondrous invention and used it in countless applications, as it revolutionized human life that surpassed all imaginations. Today, the laser field has become one of the important fields in all different aspects of life, as its appearance led to a scientific and technical breakthrough.

The word laser is an acronym for light amplification by stimulated emission of radiation. A laser is a device that generates light in the form of a laser beam. A laser beam differs from a beam of

light in that its rays are monochromatic (one color), coherent (of the same frequency and waveform), and balanced (going in the same direction).[1] The laser device consists of three main parts: A power source (usually referred to as a pump or pumping source), laser medium and Two or more mirrors that make up the transponders. The majority of lasers in use today fall into three categories. These are: Solid state lasers. -Gas lasers (atomic, ionic, molecular lasers) and Liquid lasers (dye laser).

The lasers most commonly used in medicine are neodymium: YAG lasers (Solid state), Argon ion lasers (ionic gas), CO₂ (molecular gas) and most recently dye (liquid) lasers. Lasers in medicine help medicine to work with high accuracy by focusing on a small area and reducing the damage to the adjacent areas of the body, where the pain, swelling and tissue damage are less compared to traditional surgeries, but laser treatment may be expensive and requires many treatment sessions.

2.Literature Survey

- Muhammad Ali Ansari and others in 2013 A study of the thermal properties of biological tissues was conducted. During all heating based medical applications such as hair removal, cancer treatment or laser-induced interstitial thermotherapy (LITT), In 1967 d. Kelly published the first paper on laser coagulation. He applied a laser to pre-retinal hemorrhage in rabbits and confirmed that for the higher power setting, retinal nerve fibers might be destroyed³. The laser can increase the temperature of cells and denature proteins and collagen which leads to tissue coagulation and can necrosis cells. Red blood cells tend to absorb green light, so a green light laser is a good option for diabetic eyes [2]
- Robert Levine et al in 2017 experimentally proved the ablation of hyperplastic oral soft tissue with the flexible fiber waveguide 10,600nm CO₂ 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 CO₂ laser a perfect surgical tool for treating oral soft-tissue lesions, including the inflamed operculum.[3]
- Sergei Borisovich Kislev Sergei Vladimirovich Moskvina December 2018 Their study was on the use of laser therapy for fibromyalgia patients: a critical review of the literature Pain management remains - despite many narcotic medications - an urgent task. If the goal is to achieve permanent pain relief – not to temporarily mask the pain (hiding the pathology) - this goal can only be achieved by treating pain with the most common and effective natural treatment method, Low Level Laser Therapy (LLLT). Treatment methods differ mainly in the case of neuropathic pain (nonspecific, primary), which includes pain with localization of trigger points (TP) and nociceptive (specific, secondary), which includes all types of traumatic pain, inflammatory, etc. [4]
- Marshall et al in 2020 The experiment showed that longer wavelengths lead to decreasing energy absorption and refraction index in the melanin, as well as a reduction of hemoglobin energy absorption. Longer wavelengths increase the probability of the interaction with water particles and its own light absorption. We conclude that reflection and melanin absorption are negligible for wavelengths higher than 1000 nm due to the ability to penetrate higher amounts of energy into the

tissue. Additionally, water absorption increases with the longer wavelengths and refraction index and hemoglobin absorption are reduced. [5]

- Mohammed Reza Razaki, Muhammed Hussain Ghazimoradi, Shervin Afzali, Ehsan violin, Izz El-Din Mohajerani, Afshan Shirkavand, Shirin Farivar February 13, 2021, Effect of low-level laser on the efficacy of liposomal doxorubicin in a melanoma cell line. Enhanced delivery of doxorubicin in response to laser effect. His study was that the use of stimuli-responsive LDDS, in this case, laser-responsive, resulted in favorable conditions in cancer therapy, providing enhanced cytotoxicity to cancer cells.[6]

- Mercedes Ravandi February 13, 2021, Laser Therapy for Cardiovascular Diseases Review: Lasers in Cardiovascular Diseases One of the advantages of using laser therapy in cardiovascular diseases is the lack of surgical intervention. It also reduces the pain of the treatment process and prevents huge surgical incisions and bleeding throughout the procedure. Laser therapy can provide an alternative method for treating the ischemic heart area and creating an anastomosis of the vessels.[7]

- Nisreen Al-Zind Laila Ait Vishtami Parveen Mansoori Mohsen Fateh Afshan Shirkavand February 2021 Clinical effect of non-thermal carbon dioxide laser therapy (NTCLT) on analgesia for oral aphthous ulcers of Behçet's disease, Pain relief effects of NTCLT on BD oral ulcers. The results of this study indicate that NTCLT can be proposed as a hopeful measure for important values and Immediate relief from oral aphthous ulcers caused by Behçet's disease without any visible adverse thermal effects.[8]

Since their first appearance in 1960, lasers have been seen as potentially useful light sources for medical applications, because they have three characteristics which distinguish them from conventional light sources: their directivity, the ability to use them in pulsed mode, and their monochromaticity. Directivity, i.e., the emission in a narrow parallel beam, allows the transmission of light (whether visible, near infra- red or near ultraviolet) with the aid of an optical fiber of small diameter (50 to 600 μm). Very short emission times (pulsed mode) from milliseconds to femtoseconds (10⁻³ to 10⁻¹⁵ s), deliver extremely high instantaneous power which can be as high as Gigawatts (10⁹ W), with different tissue effects than one obtains with continuous exposures. Emission of a single color, a property known as monochromaticity, allows the use of a laser beam to produce wavelength selective effects, as an alternative to using a filtered broad-band light source, which is inefficient.

Diode lasers are used in a variety of important medical applications, such as phototherapy, diagnosis, and surgical treatment. Diode laser technologies offer many advantages. They reduce blood during surgery, reduce swelling and remove pain. It can also be used for blood vessel clotting, cutting tissue, and removing cancer cells . A typical solid-state laser consists of two components (optics and electronics) integrated into a single box. The cavity containing spherical mirrors at each end is filled with a crystalline medium, which then concentrates the injected light into a bright, high-intensity beam. This mechanism can be used in soft tissue surgeries in dentistry, ophthalmology, and dermatology.

A gas laser uses a mixture of gases inside a small compartment. After an external source voltage is applied to the chamber, the atoms in the gas are excited, resulting in light in the process. Since

water absorbs this frequency of light very well, a gas laser is useful in surgeries. They are prominent in laser facelifts and skin peels and are currently being explored as an alternative to surgical threads and beard tissues. Dye lasers use dye as an intermediate, often in a liquid solution. They are used in many medical procedures, including the treatment of vascular lesions, laser angioplasty, pyrolysis, urology, and diagnostics. This laser consists of carbon dioxide. The carbon dioxide laser treats a number of skin disorders. The laser has the ability to enter and cut the affected layer of skin outside the body without causing injury. This allows the skin to heal and rebuild the layer of skin that was removed. This laser uses very little laser energy to amplify light using rare earth elements such as erbium. Fiber lasers are very popular in endoscopy as they help the doctor diagnose a patient while looking at specific parts of the body. Fiber lasers are also used to remove fat and tattoos. The fibrous is completely made of ionic bonds, like other lasers, but it is said that it shines more than Others. This is an ultraviolet laser that uses noble gases such as helium and argon. Excimer lasers are commonly used in LASIK eye surgery. Dermatologists use excimer laser to treat vitiligo. Diode lasers are used either as laser pumps or as direct sources of treatment due to their small size, efficiency, low cost, and ability to produce large optical energies. Used in hair removal, teeth, eyes, and other skin diseases diode laser light directly. The wavelength of the light is critical to the effectiveness of the treatment, and the laser illumination is chosen to match the absorption of the skin, blood, organ components or the injected dye.

It is a type of surgery that uses the cutting power of a laser beam to make bloodless cuts in tissue or remove a surface lesion such as a skin tumor. There are a number of different types of lasers that differ in emitted light wavelengths and power ranges and in their ability to clot, cut, or vaporize Tissue When using laser in medicine, potential advantages for both surgeons and patients are provided.

3. Tissues

Tissues are formed from the assemblage of cells and intercellular materials in various proportions in which one component predominates. In nervous tissue as an example, nerve cells predominate while in connective tissues such as Ligaments and Tendons, intercellular fibrous materials predominate. A tissue could therefore be described as comprising cells, which share structural and functional similarities and intercellular materials. In the course of development of the body, cells undergo specialization following which they aggregate, based on functional and structural similarities to form body tissues. This arrangement is responsible for the high level of organization and distribution of labor in the body. When tissues are assembled in various proportions to form a functional entity, an Organ is said to be formed. The organization of tissues within an organ determines the structure as well as the functional capabilities of the organ. There are four main types of tissues within the human body. These are commonly referred to as the Primary (Basic) tissues of the body. The basic tissues of the body include: Epithelial tissue covers the external and internal surfaces, including cavities and tubes of the body. Three different shapes of cells are encountered in the epithelium.

This tissue connects cells and other tissues of the body, offering structural and metabolic support. It also serves as a medium of conveying nutrients to and removing waste from tissues and body organs. It is composed of specialized cells (Fibroblasts), intercellular fibrous materials (Collagen, Reticular and elastic fibers) and an extracellular fluid medium called Matrix (Ground substance).

The connective tissue is the most abundant tissue in the body.

4. BASIC EFFECTS OF LASER ON TISSUES

There are 5 basic effects of laser on tissues as follows:

1. Thermal effects.
2. Mechanical effects.
3. The photo ablative effect.
4. The photodynamic effect.
5. Photochemical and Photobiological effects.

Thermal effects of a laser beam can be described as one of the following three types, depending on the degree and the duration of tissue heating:

- A. Hyperthermia:
- B. Coagulation:
- C. Volatilization:

Figure 11 - Phenomena of thermal effects of laser

Application of Thermal effects of lasers:

1. Coagulation/ cauterizing of tissues.
2. Tissue vaporization for incising or excising.

Recently, thermal power of laser has been widely used by surgeons to:

- a- Cut into tissues (carbon dioxide laser scalpel).
- b- Stop internal hemorrhage (Neodymium: YAG and argon laser photocoagulation).
- c- Treat tumors.

Mechanical effects

Nd: YAG lasers, a very high intensity of luminous flux over a small area (between 1010 and 1012 W/cm²) ionizes atoms and creates a plasma. At the boundary of the ionized region, there is a very high-pressure gradient which causes the propagation of a shock wave. It is the expansion of this shock wave which causes the destructive effect.

Application of mechanical effects:

General Surgery: coetaneous angiomas.

- a. Eye: principally in ophthalmology
- b. Urology: Endoscopic removal of kidney stone

The photo ablative effect of laser: This effect is defined by as a pure ablation of material without thermal lesions at the margins, such as one would get with a scalpel. It occurs because of the

principle of dissociation. The molecular bonds are broken, and the tissue component are vaporized, without generation of any heat at the edges.

Uses of Photo ablative effects of laser:

Orthopedic Surgery:

1. This procedure is for patients presenting with refraction problems.
2. Myopia
3. Hypermetropia,
4. keratitis
5. keratinization,
6. keratoplasty

➤ The photo ablative effect offers no practical advantage for making incisions or for ablating vascular tissues because they will bleed in the same way as with a scalpel. It can only be used on tissues which will not bleed

The photodynamic effect Photodynamic therapy (PDT) is based on photoactive drugs that produce excited singlet-state oxygen molecules from local (ground-state) oxygen molecules under illumination with visible light. The singlet oxygen produces reactive oxygen species, primarily free radicals such as $\cdot\text{OH}$. These free radicals attack DNA and other vital biomolecules in the cell, leading to cell death. Due to the limited tissue penetration of visible light, PDT has mostly been utilized for skin cancers.

Photodynamic therapy works by the patient receiving a photosensitizing agent or photosensitizer which is a drug that exposes cancerous cells to the laser light which kills these cells. The photosensitizer has the ability to differentiate between good body cells & cancerous cells, and will not diffuse in the good cells, leaving to expose only cancerous cells.

5. Conclusion

in conclusion, laser therapy has piqued the interest of professionals in practically every discipline of medicine. There are several risks associated with laser therapy, as previously stated. To achieve an effective therapeutic method in laser therapy, two important points should be considered: the first is the large capacity of a laser for medical applications, which implies more efforts to improve physical and clinical parameters such as light wavelength, duration, fractionation, and tissue targets, and the second is the consideration of its complication to reduce unfavorable side effects.

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