

Laser Applications in Dermatology

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Abstract:

Laser represents one of the important topics that have taken over the scientific arena in the field of medicine, as it is the most important modern technology that has proven successful, especially in the field of skin diseases, including acne, removing scars and warts, and treating the effects of burns, and others, as it contributed to giving simple solutions that were considered complicated in the above, and this does not mean that there is no damage to it, but the damage is considered insignificant compared to the results achieved, and this is due to the misuse of the device or the patient's failure to follow the advice given to him by the doctor

Scientific studies are still in place in this field to achieve more progress and complete the treatment of the patient with the least damage.

Among the pathological skin disorders that were treated in this study are wart removal and blood nevus removal. By treating these cases using laser, we concluded the following: Minimize bleeding, Not all of the treated cells have been completely damaged or thickened. There are not many secondary infections. After a period of treatment, the skin's original color returns and there is no pigmentation.

1. Introduction

The acronym LASER stands for Light Amplification by Stimulated Emission of Radiation. They are of interest because the light emitted from a laser has several distinctive features that separates it from that from other sources. For example, laser light is distinctly monochromatic compared to say, a lightbulb or the sun. It is directional, rather than being radiated isotropically, and importantly, spatially and temporally coherent to a much higher degree than other light sources.

The basic principle of lasing action is the stimulated transition of an electron in a high energy level to a lower one, emitting a photon with the same properties as the incident photon that initiated the transition. This requires that there are more electrons in the upper state than the lower, or the incident photon would be absorbed. This is called a 'population inversion' and is an unusual state, as a thermal Boltzmann distribution of population in an atom (where 'atom' can be taken to include ions and molecules) would be for there to be more electrons in the lower energy level. The basic form of a laser consists of a laser gain medium, a pump source and a cavity, shown schematically in fig.(1) The pump source (which may be a flashlamp, electrical discharge, other laser etc.) creates a population inversion in the laser medium [1].

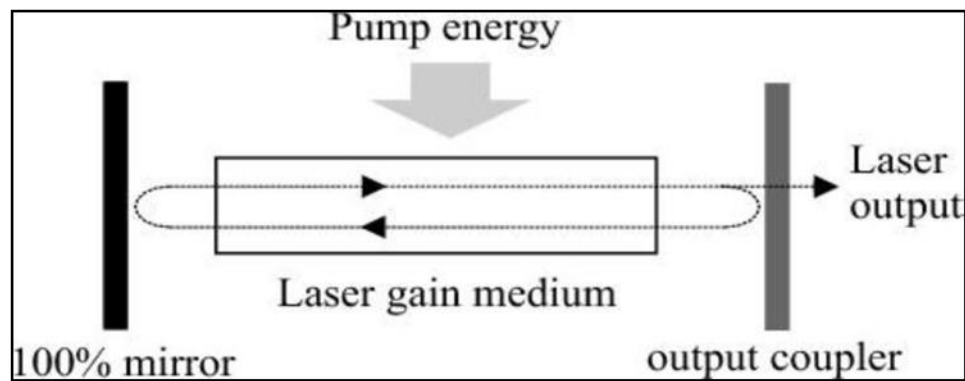


Fig. (1:1) Laser cavity [1]

2. A brief history of the laser

In 1917, Albert Einstein laid the theoretical foundations. (photoelectric) on which the work of the laser is based, in his research on the photoelectric phenomenon, In this phenomenon, scientists noticed that when electromagnetic light radiation is shed on a metal surface, the Electrons are emitted from this surface only if the frequency of light exceeds a certain limit value The light is less than that, the electrons are never emitted, no matter how intense the light is. In 1905, Einstein solved this mystery Prove that light is of a wave and particle nature, contrary to the prevailing belief at that time, which is that light Only wave in nature. Einstein proved that light, as well as other types of electromagnetic radiation It is not an absorbed stream of energy, but consists of small units, each carrying a specific amount of energy It is proportional to the amount of energy carried by one photon of light (photons). They are called photons directly with the frequency of light. Einstein studied interactions between radiations Electromagnetism and the atoms of matter and enable the development of equations that govern these interactions, which were named as After his name, he predicted, through these equations, the existence of what is called the phenomenon of stimulated emission on which the laser is based. And in 1960 The physicist Theodore Maiman managed to manufacture the first laser in the visible light range. The sapphire rod was wound with a light bulb consisting of a glass tube filled with xenon gas. And when you turn on The light from the electric lamp excited the chromium atoms in the ruby, so they arose Pure red light emitted in pulses from

one side of the sapphire rod. In 1962, the American engineer Robert Hall managed to Semiconductor laser manufacturing, which is characterized by its small size And in 1964

The carbon dioxide laser has been manufactured, which is characterized by its high radiation power [2].

3. Unique properties of a laser

The beam of light generated by a typical laser can have many unique properties. When comparing the properties of laser light to those of other light sources, it can be readily recognized that the values of various parameters for laser light either greatly exceed or are much more restrictive than the values for many common light sources. We never use lasers for street illumination or for illumination within our houses. Lasers generally have a narrower frequency distribution, a much higher intensity, a much greater degree of collimation, or a much shorter pulse duration than that available from more common types of light sources. Therefore, we do use them in compact disc players and in medical applications as a surgical knife or for welding detached retinas. We also use them in communications systems and in radar and military targeting applications, among many other areas. A laser is a specialized light source that should be used only when its unique properties are required. [3].

4. Types of laser

Depending on the nature of the active media, lasers are classified into three main categories, namely, solid, liquid, and gas. Scientists and researchers have investigated a wide variety of laser materials as active media in each category since 1958, when lasing action was observed in ruby crystal [4].

5. Solid state laser

The active medium is a crystal of solid material into which active ions are introduced for the purpose of laser generation. The most common laser crystals are sapphire (ruby), neodymium (Nd:YAG), neodymium- glass (Nd:glass), alexandrite, and titanium (Ti:sapphire) [5].

6. Liquid state laser

Liquid lasers are optically pumped lasers in which the gain medium is a liquid at room temperature. And the most successful of all liquid lasers are dye lasers. These lasers generate broad-band laser light from the excited energy states of organic dyes dissolved in liquid solvents. Output can be either pulsed or CW and spans the spectrum from the near- UV to the near-IR, depending on the dye used [6].

7. Gas state laser

Gas lasers are widely available in almost all power (milliwatts to megawatts) and wavelengths (UV-IR) and can be operated in pulsed and continuous modes. Based on the nature of active media, there are three types of gas lasers via atomic, ionic, and molecular. Most of the gas lasers are pumped by electrical discharge. Electrons in the discharge tube are accelerated by electric field between the electrodes. These accelerated electrons collide with atoms, ions, or molecules in the active media and induce transition to higher energy levels to achieve the condition of population inversion and stimulated emission [4].

8. Previous study

1. **In 2005, Jamal J. I. Findakly**, a case study was conducted on 15 patients of both sexes with warts, their ages ranged between 7 and 40. The treatment warts were in the most common places in the body (such as the hand, foot, and face). In the current work, the patients were treated after they were divided into 3 groups. Each group was treated with a damped laser with a wavelength of 810 nm, a power of 9, 12, and 15 watts, an irradiation time of 200 ms, and a pulse duration of 200 ms. the patients' cases were followed for three months. The results were complete recovery of the wart and no recurrence of the disease after recovery, and there was no fibrosis. In some of them, a change in the skin color of the laser-treated area appeared, and some swelling and crusts appeared for a week after the laser treatment, then they disappeared [7].
2. **In 2006, M. Landthaler et al.**, Laser therapy has become an important therapeutic modalit in dermatology. Various lasers can be used for the treatment of different vascular and non-vascular lesions. According to our results, vascular lesions constitute the most important indication for laser therapy in dermatology [8].
3. **In 2012, Sepehr et al.**, used the CO₂ laser to treat inflammatory and surgical scars, and excellent results were achieved. He also explained that the use of a non-ablative laser for treatment has moderate side effects and fast recovery times, and early intervention, especially in surgical wounds, can lead to improved results regarding scars [9].
4. **In 2012, P. Arora et al.**, The treatment of skin problems has been transformed by lasers including Nd-YAG, alexandrite. The several research studies included in this review's documentation emphasize the value of laser settings for maximizing effectiveness and minimizing negative effects. Melasma treatment requires careful consideration of the appropriate laser and settings. Moreover, lasers should only be used in situations when topical therapy or chemical peels have failed to improve the condition[10].
5. **In 2017, Larosa et al.**, were study conducted they use laser to treatment of skin disease in women. A number of conditions that predominantly occur in women and that have a paucity of effective treatments include rosacea, connective tissue disease, melasma, , lichen sclerosus (LS), notalgia paresthetica and macular amyloidosis, and syringomas. Laser therapy is an important option for the treatment of patients with these conditions[11].
6. **In 2019, Essam-Elden M. Mohamed et al.**, To evaluate the effectiveness of 577-nm yellow laser in the treatment of some vascular skin diseases. We concluded from this study that a single pass of 577-nm yellow can be used successfully in the treatment of facial PWS, papulopustular rosacea, facial telangiectasia, and facial erythema with minimal side effects [12].
7. **In 2021,Sadiq Lafta et al.**, were employed CO₂ lasers and Nd-YAG lasers with wavelengths of 1064 nm and 10600 nm to cure skin problems, including melisma[13].
8. **In 2022, Steven Paul Nisticò et al.**, This study aimed to evaluate the efficacy and safety of the QSF Nd:YAG laser in the treatment of scars in Asian patients. A total of 29 subjects were treated with a 1064 nm QSF laser. The efficacy of the treatment was evaluated as an improvement in acne scars was observed, and no side effects were observed except for some slight erythematous reactions. The results confirm that the 1064nm QSF Nd:YAG laser is a safe and effective technique for treating scars in Asian [14].

Research problem:

- High cost of the devices.
- The poor quality of the devices if they are available.

- Some people worked on these devices who do not have experience or specialization in this field.
- Some people are afraid of using lasers for several reasons, including their belief that it causes cancer, so awareness must be raised in this regard.

The aim of the research:

Is to study the applications of laser in the treatment of dermatology

1. Dermatology

They are diseases that affect the human skin. These diseases may be communicable or non-communicable, depending on The type of disease, as the skin is one of the most vulnerable organs in the body to external and environmental influences and related to the rest body parts such as: nervous system, endocrine glands and others. Which sends signals that appear on the skin [15].

Human skin is a stratified epithelium, each tissue layer consisting of different cell types that perform distinct functions. The underlying hypodermis (or subcutis), the dermis, and the overlying epidermis can all be broadly categorized (Fig.1), The stratum corneum, stratum granulosum, stratum spinosum, and stratum basal are additional divisions of the skin that can be made from the outside in. The stratum basal and stratum spinosum are collectively known as the Malpighian layer. An additional layer, the stratum lucidum (clear layer) can be observed on parts of the body with thickened skin, such as the palm and sole of the foot. However, The lower portion of the stratum corneum, rather than being regarded as a separate epidermal layer, is the stratum lucidum. In addition, there are appendageal characteristics like sweat ducts and hair follicles that travel through different skin layers. [16].

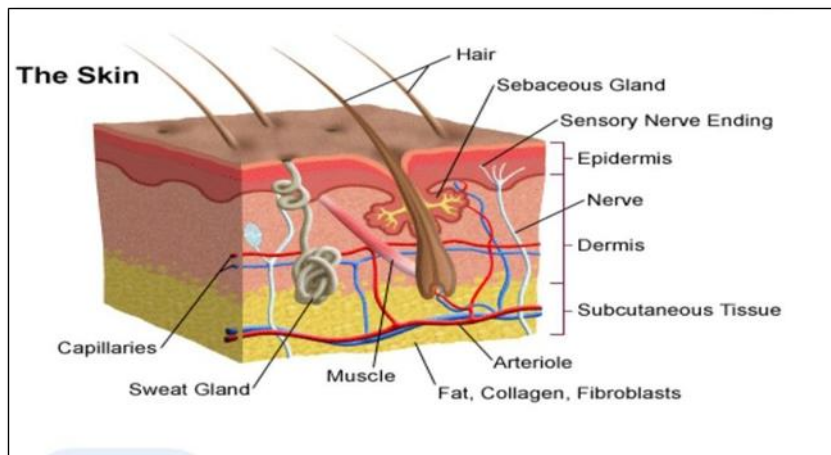


Fig (2:1) A diagrammatic representation of the structure of human skin in cross section.

2. Human skin and laser interaction

The nature of interaction of all laser light with biological tissue can be described by the following phenomena:

Reflection: There is always a degree of reflection of laser light from the epidermis.

Transmission: The laser light is transmitted through tissues to their target.

Scattering: This happens after the epidermis and deeper tissues are penetrated by the laser radiation. The third significant aspect of tissue interaction during laser treatment is scattering. A very thorough interaction between water, lipids, and the cellular membrane scatters the majority of light penetrating the tissue. Short wavelengths of visible light exhibit higher scattering.

Absorption: Absorbed laser light may cause tissue coagulation or vaporization. Laser light affects mainly pigment, hemoglobin or water [17]. The skin has a thickness of about 100 micrometers, can absorb laser energy, and needs to be adequately cooled before treatment. The upper dermis has a thickness of 400 micrometers, and in this layer, which is made up of tissues supporting the sweat glands in between the hair follicles and the large blood vessels, are the vascular loops that branch out from the superficial arterial network supplied by the arteries in the lower dermis. When we direct the laser towards the skin, the light penetrates the surface of the skin and is absorbed by the target tissue, and a small part of it is reflected, as the photon focuses its power on the distinct target chromosphere, and then the power is transformed into heat that is distributed to the adjacent tissue by transmission or radiation in the cells, and thus begins cell proteins in fusion, cell walls, and their contents at a temperature of 40, and the amount of effect depends on the power of the laser and the area that is exposed to the laser, the appropriate wavelength, the size of the spot, the time period of exposure, and the color of the tissue [18].

3. *Types of skin diseases treated with laser*

1. *Vascular birthmarks*

Birthmarks on the skin of a newborn or that develop on a child's skin can be upsetting for parents. Most birthmarks appear on the skin when a baby is born. Some develop on a child's skin after birth. No matter when they develop, most birthmarks are harmless and many even go away on their own or shrink over time. Sometimes birthmarks are associated with other health problems. There are many types of vascular birthmarks. Vascular birthmarks are caused by either increased or abnormal blood vessels within the skin. These blood vessels either do not form correctly or fill with too much blood, resulting in redness on the skin. [19].



Fig (2:2) vascular birthmarks before and after treatment

2. *Warts*

It is a raised skin bump or small lump in the skin that has texture. rough, with a color similar to the color of the skin, or it may be slightly darker than it. Contrary to the popular beliefs inherited, warts do not have Roots, as they grow entirely within the upper layer of the skin only, i.e., within the epidermal layer, and does not move to the epidermis. The interior is known as the dermis [20]. The concept behind laser therapy is the photothermal or photomechanical destruction of the target tissue. Target structures capture coherent monochromatic light with a particular fluence and wavelength. The target object is destroyed as a result of the conversion of light energy into thermal energy. [21].



Fig (2:3) (A) Periungual wart. (B) Crusts were formed three days after treatment.

3. Scars

Scar formation is the natural response of tissue to wound healing following an injury that is significant enough to elicit this host tissue response. These scars may be aesthetically unappealing, and if they are hypertrophic, they may be painful as well. Common scar removal treatments include laser surgery. Your dermatologist can use a laser to remove the outer layer of your skin, contour areas of acne scars, or lighten redness around healed acne lesions. Various types of lasers are used, depending on whether the acne scar is raised or flat, and you may need several days to heal [22].



Fig (2:4) Erbium Yag laser for acne scar

1.4 Types of lasers used in the treatment of skin diseases

The most prevalent types of lasers for treating skin conditions are displayed in the following table [23].

Table 1 Commonly used dermatologic lasers		
Wavelength (nm)	Laser	Chromophore
308 (UV-B)	Excimer	DNA/RNA
532 (green)	KTP	Hemoglobin
	Q-switched Nd:YAG	Tattoo ink (red)
585-600 (yellow)	Pulsed dye	Hemoglobin
		Hematoporphyrins
694 (red)	Q-switched ruby	Tattoo ink (black, blue)
	Long-pulsed ruby	Melanin
755 (infrared)	Q-switched alexandrite	Tattoo ink (blue, black, green)
	Long-pulsed alexandrite	Melanin
810 (infrared)	Diode	Melanin
1064 (infrared)	Q-switched Nd:YAG	Tattoo ink
	Long pulsed Nd:YAG	Melanin
1320 (infrared)	Long pulsed Nd:YAG	Water
1450 (infrared)	Diode	Water
1540 (infrared)	Er:glass	Water
2940 (infrared)	Er:YAG	Water
10,600 (infrared)	carbon dioxide	Water

The first case: Removal of warts

A number of cases infected with warts in different parts of the body, in the hands and feet, were chosen in an intense manner, where the laser beam was directed from the outer periphery of the wart towards the center.

Removal is generally done by the following three operations: burning with evaporation of the water content of the infected cells, then removal is done using curt, then cauterization of the area spurious of blood (i.e. the process of coagulation of surface blood vessels) and the results were good in terms of ease of removal and the absence of bleeding with the shortening of time As the removal does not need more than one session.

A diode laser with a wavelength of 810 nm was used to remove warts, with a power of 15 watts, using an optical fiber, as it was moved starting from the outer edges of the wart and descending to the center in a circular manner. The recovery rate was 100% after the treatment period, which lasted

for more than From three months, where the removal takes place in one session, and then follows up clinically.

The following pictures show the treatment of the first case, where we notice the presence of warts spread on the surface of the palm, and the result was ideal and positive.



a. The condition of the wart before treatment



b. immediately after removal



c. After 2 weeks of treatment



d. Final recovery after 6 months

Fig.5: Pictures representing the condition of the wart before and after treatment

The second case: Removal of the bloody birthmark

It is a lobe or tumor that is the same color as the skin in various places of the body, and the causes of its infection is a defect during the genetic growth in the capillary blood vessels during the growth of the vascular system.

A small nevus of about 0.5 cm was treated with skin color in the knee area, and it was removed using a diode laser device, with a pulsed mode of operation. The case was followed up for one week, then two weeks, and the result was positive. The condition did not return after eight months, knowing that it had been previously treated by specialists in this field using cosmetics and the method of electric cautery, but it returned after a period of months.



a. Birthmark before treatment



b. after treatment

Conclusions

Through the treatment of the aforementioned cases, a good result was reached by using a diode laser to remove skin deformities, for the following reasons:

1. There will be no further injuries.
2. Minimizing bleeding
3. Not all of the treated cells have been completely damaged or thickened.
4. There are not many secondary infections.
5. After a period of treatment, the skin's original color returns and there is no pigmentat.
6. Shortening the recovery time.

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