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# EFFECTS OF THE LASER AND ITS APPLICATION IN ORAL SURGERY

Gjorovska Maja, Kacarska M
University Department of Oral Surgery, Faculty of Dental Medicine

**Abstract**

The rapid advancement of technology enabled invention of highly sophisticated laser scalpels that are used in oral surgery and have proved to achieve better results.
The wider application of the laser in dentistry is due to the following effects of the laser beam on organic tissues:

1. Photostimulating effect restores cell's function and stimulates its activity.
2. Photothermal effect causes coagulation of the blood vessels, thus providing a dry working field.
3. Photomechanical effect (ablative effect) evaporates the water from tissues, and so the soft tissue is cut and remodeled.
4. Photodynamic effect removes the tumor cells sensitized by chromophore. After intravenously administering hemoporphyrin, it cleans healthy cells from chromophore for 1-2 days, but it is retained for 12 days in tumor cells. The laser is absorbed in the chromophore and destroys the marked cells.

It was a challenge and a purpose to discuss and emphasize the effects and advantages of laser surgery. At the University Department of Oral Surgery various clinical cases were treated: removal of the labial frenulum and hyperplasia of the mucous membrane (epulis fissuratum), deepening of the vestibular fornix, gingivectomy and treatment of chemical scar.

***Key words:*** laser, labial frenulum, frenulectomy, fibrous hyperplasia, gingivectomy, chemical scar

## Introduction

Man and all living organisms on our planet Earth are exposed to some kind of radiation on a daily basis. Radiation as one basic form of energy can be natural and artificial. The natural radiation is emitted from the Sun, Earth, rocks, the Cosmos.Man invented the artificial radiation by constructing various appliances and using radioactive elements. Radiation, either natural or artificial, can cause positive or negative changes, and therefore can initiate, support, damage or destroy life. Radiation is the source of life or the door of death [1].

The effects of radiation depend on the dose of energy that is absorbed in the tissue and on the tissue itself. The main sources of radiation are widely used in atomic plants, industry, communications, medicine and dentistry. Artificial sources of light are the systems-lasers. Laser (LASER-Light Amplification by Stimulated Emission of Radiation) is a physical term that indicates the intensification of light emitted by radiation. The beginnings of the use of laser light date back to the early years of the last century, and research prior to laser technology was in the field of physics known as quantum mechanics whose founders were Max Planck and Albert Einstein. Einstein presented the idea of the double nature of light: wave and particle (photon). This resulted in explanation of several phenomena such as:

***Spontaneous emission*** - If a photon hits a stable atom, the electrons in that atom can absorb or emit that photon. This phenomenon occurs constantly in the nature, but the effect is not visible because absorption dominates over emission.

***Stimulated emission*** - What happens if a photon hits an excited atom? According to Einstein the atom emits two photons and returns to a low energy state. These photons have specific properties: same energy, same color-wavelength (monochrome), move in the same direction - they are completely coherent.

***Population Inversion*** - Another 43 years of work were needed in order to get today laser technology. What led to the laser effect is called the population inversion, i.e. the need for existence and holding more atoms in the excited state and emptying all of the atoms at the same time. Atoms in the excited state survive 10 ns and it is not enough to create population inversion. But there are specific substances that possess the so-called metastable energy level, and electrons found at that level remain excited for 1 ms, enough to be synchronized with the rest. Such specific substances are: Er.Yag, Nd.Yag, CO2 and others.

Devices emitting laser radiation must possess:

Active medium - a matter on which the specific wavelength of the light depends on which the laser operates and it can be in gaseous, liquid and solid state.

Energy source - a xenon lamp that stimulates the atoms of the active medium for emission of radiation.

Resonant chamber - highly polished mirrors of which one is half-permeable. The generated photons in the interior of the chamber are reflected from the mirrors, and hence more atoms are attracted to their path. When the density of photons crosses the critical level, some of them emerge through the half-permeable mirror as a laser beam that is coherent, monochromatic and one-way.

A laser-radiated beam is much better focused than a beam emitted by any other light source. This has been proved by presenting the experiment made in 1962. When a laser beam was sent to the Moon at a distance of about 400,000 km and illuminated a surface of 3 km across the Moon, as opposed to the beam emitted by another light source that illuminated an area of 40000 km.[1]

The first dental laser was built in 1964 by Stem and Goldman. In 1967, the first report on the effects of a very low dose of ruby beam was presented. Since then, the laser apparatus has been improved from a technical point of view almost to perfection in order to enable faster, simpler, more precise intervention with superior clinical results.

**Effects of the laser beam**

The tissue laser beam can be reflected, broken down, transmitted, and absorbed. Only the beam that is absorbed in the tissue achieves the maximum effect for which the laser is intended. The laser effect on the tissues can be divided into several categories:

1. ***Photostimulation effect*** - under the action of low energy lasers - LLL with a wavelength of 600-900 nm allows return of cell function to normal and stimulates its activity. This effect is one of the most perceived phenomena of the laser beam- tissue interaction. Light energy acts on intracellular biomolecules and allows the return of cell function to normal.[2] The biostimulating effect occurs as a result of polarization of the cell membrane by:

- Acceleration of B endorphin production that inhibits the feeling of pain
- Low inflammation
- In depth formation of fibrous tissue
- Formation of new blood vessels
- Change in the biochemical behavior of ATP and metabolism acceleration
- Increased acetyl choline and facilitated neurotransmission
- Stimulation of mitochondrial activity

- Activation of biological receptors (chromophores) that accelerate natural defense in the presence of injury and inflammation
- Regulation of the cellular membrane potential between ions of Na +, Cl - and K +
- Better histamine response
- Facilitation of lymphatic drainage
- Edema reduction
- Collagen preservation [3,4]

All these stimulate the immune response, stimulate healing and relieve symptoms

2. ***Photothermal effect*** **-** laser tissue energy is transformed into heat energy and depending on the parameters, it can cause blood vessel coagulation or damage blood vessels because protein coagulation factors are sensitive to temperature defeat.

3. ***Photomechanical*** effect - the ablative effect is achieved by rapid and selective evaporation of the water from the tissues - vaporization. The ***expansion*** of the tissue water generates high pressures, causing tissue removal of the microscopic tissue.

4. ***Photodynamic*** effect - this effect is used in the removal of tumor cells sensitized by chromophore. After intravenous hemoporphyrin intake cleans chromophore cells for 1-2 days while in the tumor cells it remains for retaining 12 days. The laser is absorbed into the chromophore and destroys the labeled tumor cells.

The effect of the laser beam on the tissue depends on several parameters, of which the most important are: wavelength of the beam, energy density per unit area, energy density per unit time, frequency, and more [5].

Fotona III Fidelis laser - MeDys GmbH, Germany featuring two lasers Er: Yag and Nd: Yag in a single system is used at our Clinic of Oral Surgery (Table 1).

**Table 1.** Wavelengths, primary chromophores and application of Er:YAG and Nd:YAG lasers

| Laser Type | Wavelength (nm) | Active Medium | Absorbing Chromophores | Applications |
|---|---|---|---|---|
| **Er:Yag** | 2940 | Erbium in yttrium-aluminium-garnet | Water, hydroxyapatite | Ablation of hard dental tissue, cutting of soft dental tissue with/without coagulation, disinfection |
| **Nd:Yag** | 1064 | Neodymium in yttrium-aluminum-garnet | Slight absorption in melanin and hemoglobin | Cutting and coagulation of soft dental tissue, disinfection, thermal stimulation in tooth whitening |

Hard lasers have a special place in surgery, in particular Er.Yag laser in which the cryogenic grid of the sodium-aluminum-garnet is embedded. The wavelength of Er.Yag laser is 2940 nm. This wavelength is well absorbed in water and hydroxydapatite and has a photothermal and photomechanical effect on soft and hard tissues, and its biostimulation is still under investigation. Its main applications in dentistry are:

1. Albation of hard tissues: enamel, dentin, bone.
2. Softening and ablation of soft tissues, with or without coagulation.
3. Disinfection [5].

Efficient ablation is achieved by rapid and selective evaporation of the bound water in dentine and enamel. The rapid evaporation of the water generates high pressures, causing the removal of hard tooth tissue through the so-called micro explosion. Hydroxydapatite does not melt with ablation because the whole energy of the laser is used to evaporate the water with minimal thermal effect on the surrounding tissues [5,6].

Er.Yag laser can be used in contact with or without the tissue, depending on the application. When used without a contact hand piece, the size of the exposed surface depends on the distance from the hand to the tissue. An optimum beam focus is achieved when the hand piece is approximately 7 mm away from the tissue. In contrast, when contact hand piece is used, it should be kept in gentle contact with the tooth surface or soft tissue.

The laser beam from the Er.Yag laser should never be directed towards amalgam, golden and ceramic restorations, because it loses its effect and is reflected by them.

Nd.Yag has long been used in many dental, surgical applications due to its thermo-coagulation effect. This laser can also be used for excision of pathological changes, for sterilization and closure of tissues using a low laser power.

The Nd.Yag laser in the crystalline grid of the sodium-aluminum-garnet is a built-in neodymium and is absorbed in water 10 000 times less than the Er.Yag laser, and hence it is not used for ablation of dental tissues. The wavelength of the Nd.Yag laser is 1064 nm and is absorbed into hemoglobin, melanin and other organic compounds. Itaffects the tissue through a photothermal effect [7].

Fiber optic delivery unit of Nd.Yag laser beam is in contact with the tissue, except in tooth bleaching, when it is not in contact.

The wavelength of Er.Yag and Nd.Yag lasers are invisible to the naked eye, and red diode is incorporated to make them visible as a red dot on the target tissue.

Fotona Fidelis III laser uses VSP (variable square pulse) technology that, unlike standard lasers, provides high pulse energy without long pulse tail (short lifetime of energy, controlled duration and short time of decline) and eliminates postpuls heating, drying and carbonization. We program the pulse width, energy and frequency by ourselves and create an ideal pulse according to the need and indication.

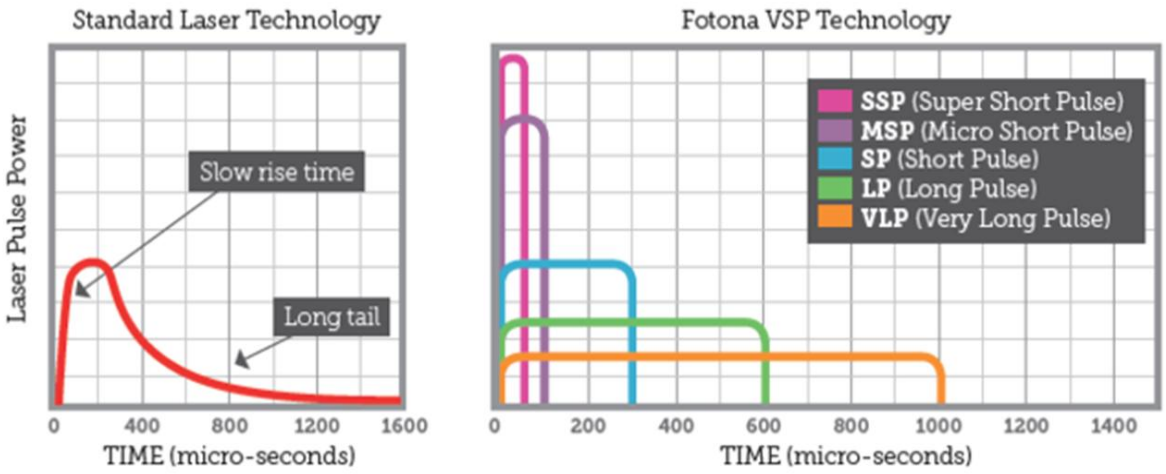


**Figure 1**. Standard laser technology in comparison with Fotona variable square pulse technology.

**Indications for laser use**

In everyday practice, the laser is used in virtually all dental disciplines.

- Removal of carious lesions and preparation of cavity
- Removal of composite fillings
- Disinfection of the root canal
- Gingivoplasty
- Gingivectomy
- Treatment of gingivitis, periodontitis, periimplantitis
- Treatment of aphthae, herpes
- Vestibuloplasty
- Apicotomy
- Frenulectomy
- Removal of vascular malformations
- Benign soft tissue changes (fibromas, lipomas)
- Gums pigmentation
- Removal of scars

**There are few contraindications using a laser:**

- Minor tissue changes
- Pregnant women
- Application over endocrine glands surfaces
- Thrombosis and thrombophlebitis

At the University Clinic for Oral Surgery at the Faculty of Dentistry in Skopje daily laser interventions are performed. The most common are: frenulectomy, vestibuloplasty, gingivectomy - clinical crown lengthening, removal of gingival hyperplasia, benign changes, scar.

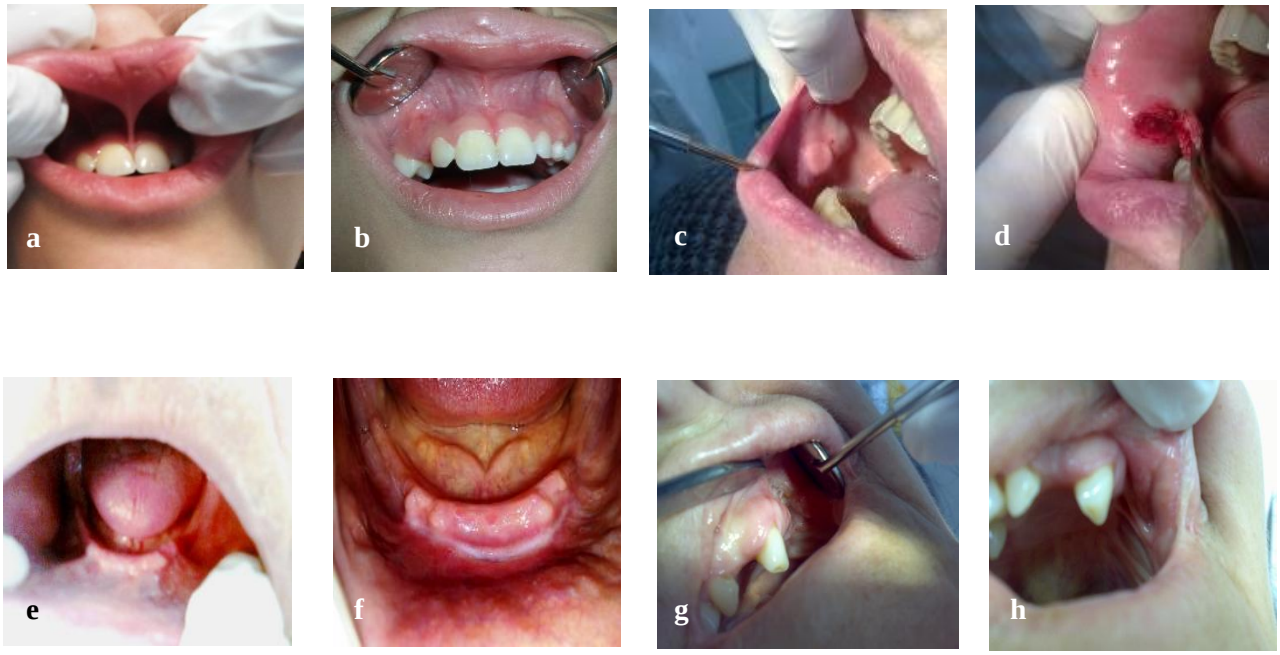


**Figure 2.** a. frenulectomy (before); b. frenulectomy (after); c. benign changes; d. benign changes; e. vestibuloplasty (before); f. vestibuloplasty (after); g. scar (before); h. scar (after)

All the interventions were performed with Fotona Fidelis lll laser ER.Yag, a non-contact hand piece with a certain pulse, adequate energy and frequency. The laser parameters can be tuned manually, or pre-programmed [8].

Lasers are used in surgery because they provide precise incisions and hemostatic control. The results of laser interaction depend on the type of laser and target tissue [1,3]. The Er. YAG laser has the highest absorption peak in water from all commercially available, approved lasers. Its unique properties allow thermal-mechanical tissue ablation of very thin layers with minimal collateral thermal sequences [5]. The healing potentials of laser irradiated tissue are exceptional. Lower thermal damage diminishes the need for collagen remodeling [6]. With less damage and remodeling of the collagen, wounds heal easier and faster. The main benefit of laser soft tissue surgery is its simplicity, speed and minimum discomfort during and after interventions. Taking these benefits into account, we propose laser surgery with Er.YAG as the most appropriate [9].

The interventions were conducted with a minimal amount of infiltrative anesthesia. Patients co-operation were exceptional, even when children were treated. Bleeding was minimal and we did not apply sutures. These surgeries could be performed with a conventional technique also [8,9]. But conventional vestibuloplasty causes a significant discomfort, pain and prolonged healing [10]. The postoperative course was without complications, absence of bleeding, pain and swelling. This is probably due to the properties of the erbium to seal the blood and lymphatic vessels that minimize the postoperative swelling, while sealing of the nerve endings reduces pain and discomfort. The recoveries were accelerated. There was no need for re-operation [8,

9,10]. The recovery of the laser wound is similar to a surgical (scalpel) wound with or without scar formation.

**Conclusion**

Application of laser in surgery enables comfort and satisfaction of both the patient and the therapist, decreased stressor component, minimal amount of infiltrative anesthesia, relatively dry work field, high precision, reliability, minimal invasiveness, no collateral thermal effects, no need for sutures and reduced postoperative morbidity (without pain, swelling, inflammation).

The recovery of a laser wound is similar to a surgical one (scalpel) wound by the formation of discrete scar tissue or without scar tissue. We believe that this study will give a modest, applicative contribution to the field of laser surgery.

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