

Paul Belliol

**Biostimulation of Orofacial Tissues:  
The Significance of Laser Therapy - a narrative review.**

Faculdade de Ciências da Saúde  
Universidade Fernando Pessoa  
Porto, 2021



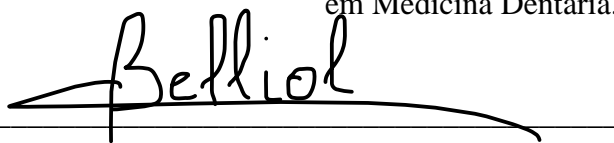
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Trabalho apresentado à  
Universidade Fernando Pessoa  
como parte dos requisitos para  
obtenção do grau de Mestre  
em Medicina Dentária.

A handwritten signature in black ink that reads "Belliol". The signature is written in a cursive style with a long horizontal stroke underneath it.

(Paul Belliol)

## RESUMO

A tecnologia laser, apesar de apresentar uma ampla gama de vantagens em intervenções terapêuticas no âmbito da medicina dentária, não é, contudo, ainda muito utilizada. A introdução do conceito de bioestimulação em medicina dentária é enriquecedor, e representa uma perspectiva para presente e futuro.

O objetivo deste trabalho de revisão narrativa é compreender a importância da tecnologia laser na bioestimulação orofacial. Foram consultados artigos, preferencialmente no período compreendido entre 2011-2021, com as palavras chave: “Laser”, “Bioestimulação”, “Low Level Laser Therapy”, “Fotobiomodulação”, “Medicina dentária”, “Medicina oral”, nas bases de dados: Pubmed e Elsevier.

O feixe laser é um tipo de radiação eletromagnética, uma amplificação da luz por emissão estimulada de radiação. Os lasers mais utilizados em odontologia são lasers de CO<sub>2</sub>, díodos de lasers, lasers de Neodymium (Nd:YAG) e lasers de Erbium (Er:YAG).

Têm sido descritos vários aspectos positivos associados à sua utilização: propriedades antimicrobianas e descontaminação, melhoria na capacidade de regeneração óssea, manutenção da hemostasia e bioestimulação. Neste contexto, está assim associado a várias vantagens terapêuticas como a redução da necessidade de suturas, a redução da dor, a diminuição da inflamação e de potenciais complicações. Resulta assim numa melhoria da reparação e recuperação, promovendo menor tempo de tratamento. Ainda, a sua aplicação é considerada fácil contudo está associada a maiores custos de tratamento.

A aplicação de laser como uma ferramenta adjuvante desempenha um papel importante na biologia dos tecidos orofaciais.

Palavras-chave: “Bioestimulação”, “Anatomia e histologia oral”, “Laserterapia”, “Fotobiomodulação”.

## **ABSTRACT**

Laser technology has several indications in dentistry, although it is not widely used and presented as a clinical alternative to various treatments. The introduction of the concept of biostimulation in odontology is enriching and represents a perspective for the present and the future.

The objective of this narrative review is to understand the importance of laser technology in orofacial biostimulation. Articles were consulted, preferably in the period 2011-2021, with the keywords: "Laser", "Biostimulation", "Low Level Laser Therapy", "Photobiomodulation", "Dentistry", "Oral Medicine", in the databases: Pubmed and Elsevier.

The laser beam is a type of electromagnetic radiation, an amplification of radiation-stimulated emission light. The most used lasers in dentistry are CO2 lasers, diode lasers, Neodymium lasers (Nd:YAG) and Erbium lasers (Er:YAG).

Several positive aspects are associated: hemostasis, antimicrobial properties and decontamination, bone regeneration and biostimulation. Thus reducing the need for sutures, promoting pain reduction, decreasing inflammation and potential complications, improving repair and recovery, promoting shorter time and they are easy to apply.

The application of laser as an adjuvant tool plays an important role in the biology of orofacial tissues.

Key words: "Biostimulation", "Anatomy and oral histology", "Lasertherapy", "Photobiomodulation".

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## I. INTRODUCTION

Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. Their history began approximately one century ago when it was theorized by a physicist named Albert Einstein (Sobouti *et al.*, 2015).

Laser radiation is an amplification of light obtained by stimulated emission of photons. These photons can be obtained via different atoms and molecules which gives the laser its wavelength and thus, properties. Photons in nature can have wavelengths of different orders of magnitude, ranging from less than 0.001 nanometers (gamma rays) to 100 000 kilometers long (extremely low frequency waves). In between, daily life radiations can be encountered such as UVs, visible light or infrareds. It is in the latter that the lasers used in odontology can be found. The beam obtained can be transported with an optic fiber to the tissues (LS - La Lettre de la Stomatologie, c. 2011).

E. Mester was a physician who experimented with the effects of lasers on skin cancer in 1967. He discovered accidentally the positive biological effects of low power lasers known as biostimulation. Its effects: control of pain and inflammation, oedema reduction, tissue regeneration, come from the light and not the heat, in contrary to ablation for example. “Biostimulation”, “photobiomodulation”, “Low Level Laser Therapy (LLLT)”, can be used indifferently to refer to the same concept (Gidel, 2017).

The objective of this paper is to analyze literature to get a better understanding of laser therapy and its role in the biostimulation of orofacial tissues. It was decided to explain the scientific basis of a laser functioning in a first time, then explore the principal types of mediums, their different uses in odontology and finally dive deeper into the biostimulation of orofacial tissues with laser therapy. The goal of this narrative review is also to put into perspective these studies and to determine if laser effectiveness, especially in the field of biostimulation, is backed up by scientific data and could prove advantageous to its uses in a dental clinic. As more and more papers get released and production costs decrease, lasers should continue to gain popularity.

## **II. METHODOLOGY**

A narrative revision of the literature was made according to the updating knowledge in odontology demonstrating the most recent scientific perspectives. The bibliographic research was conducted in Pubmed and Elsevier database and included articles published in the last 10 years (2010 to 2020) with a majority in the last 5 years (2015 to 2020). The key words used were primarily: “Laser”, “Biostimulation”, “Low Level Laser Therapy”, “Photobiomodulation”, conjointly with “dentistry”, “odontology”, “oral medicine”, as well as their Portuguese counterparts. The inclusion criteria used for this search were: open-access articles, published in English, Portuguese or French and dissertations and thesis. The exclusion criteria included duplication of articles, publications whose content does not correspond to the proposed topic and papers whose text was not fully accessible. From there, the theoretical basis of the studies was analyzed. Finally, the methodologies, results and discussions were evaluated. No specific qualitative and/or quantitative processing data technics were used, and the analysis of each text was done individually. The revision was carried out selecting 46 articles of which 43 have been found relevant for this study. Eight of them correspond to references published between 2010 and 2015. In addition, 5 papers that are indexed in different databases were also used due to their scientific appropriateness and significance in the elaboration of this work. All in all, this academic revision was realized analyzing 48 bibliographic references. Based on the limitations pointed out in the revised studies and the future perspectives provided by the authors, unanswered questions were identified, which led to prospects for further investigation.

### **III. DEVELOPMENT**

#### **1. Basic Principles**

The physical phenomenon underlying the functioning of a laser was born with quantum mechanics at the start of the 20<sup>th</sup> century. In 1917, Albert Einstein described the principles of stimulated emission in his article “On the Quantum Theory of Radiation”. It was only in 1960 that Theodore H. Maiman built the first ruby laser. Shortly after the first laser surgery was performed (1961). In 1965 laser was used for the time in dentistry. Since then, knowledge concerning laser-tissue interaction has increased, and lasers with different wavelengths have been created (Cavalcanti *et al.*, 2011; Martens, 2011).

Light in nature is said to be polychromatic, incoherent and multidirectional however a laser’s light differs from it by having a single wavelength which travels coherently in one direction through space and time (Cavalcanti *et al.*, 2011; Green, Weiss and Stern, 2011). These traits give the laser its characteristic power and precision compared to a simple flashlight.

The laser beam is an amplification of light obtained by stimulated emission of radiation from atoms or molecules of a solid, a fluid or a gas. The phenomenon by which the instrument does it, is called a “population inversion”, - it makes most of the atoms go from a fundamental state, where they have minimal energy, to an excited state. It is a state where the atoms absorbed a particle of light, or photon, and then possess an excess of energy that they “want” to release to return to a more stable ground state (Green, Weiss and Stern, 2011). Lasers can have different wavelengths depending on the medium used (Annex 1; Figure1). Mediums are placed between two mirrors, which will reflect the photons emitted. One of the mirrors is only a semi mirror that will let some of the photons pass after a certain number of bounces. This process is, in a simplified way, how the beam of the laser is created (Cavalcanti *et al.*, 2011; Martens, 2011).(Annex 1; Figure 2).

When the laser light reaches a tissue there are four possible outcomes: reflection, transmission, scattering or absorption. Reflection happens when the beam gets reflected off a surface. Reflected light can be used for example in caries detection (Martens, 2011). The beam is transmitted when the tissue allows it to go through. It can access deeper layer but does not interact or modify the target. Scattering occurs when the beam is scattered in several directions. This effect decreases its power and produces no biological effect. Finally, absorption happens when the energy of the photon is given to the tissue. This interaction has the greatest effect and modifies the tissue (Cavalcanti *et al.*, 2011; Martens, 2011).

The absorption of laser light depends on two factors: the amount of chromophore present in the tissue and whether the wavelength used corresponds to the absorption characteristics of that chromophore (Cavalcanti *et al.*, 2011; Khalkhal *et al.*, 2020). Hemoglobin, water and hydroxyapatite, for example, do not absorb the same wavelength and therefore, different lasers must be used when working in soft tissue (mostly composed of water and hemoglobin) or on a tooth (Khalkhal *et al.*, 2020; Caprioglio, Olivi and Genovese, 2017). (Annex 1; Figure 3). Scattering of laser energy is inversely proportional to wavelength to the fourth power (Cavalcanti *et al.*, 2011).

Once absorbed, light can have three basic effects: photothermal, photomechanical or photochemical. When the absorbed light is converted into heat capable of destroying the target, the effect is said to be photothermal. The heat produced can also cause a thermal expansion. This ensures the photomechanical destruction of the tissue that absorbed it as well as the creation of acoustic waves. When the photochemical effect occurs, the light absorbed creates a chemical reaction. This is the basic principle of photodynamic therapy (Cavalcanti *et al.*, 2011). (Annex 1; Figure 4).

Medical lasers are powerful instruments that can cause ocular damages to the patient and the practitioner. Professionals should be trained to use the devices and proceed with caution, protecting themselves and the patients with specially made glasses. There is a classification of lasers according to their hazardousness, allowing the user to adjust the protection needed (Gidel, 2017).

## 2. Types of Lasers Used in Odontology

Medical lasers are classified by reference of their medium's nature. Caprioglio, Olivi and Genovese (2017) explained that the choice of the laser depends on the absorption coefficient in different target chromophores for different wavelengths. The most commonly used lasers in odontology are CO<sub>2</sub> lasers, diode lasers, Neodymium lasers and Erbium lasers (Ortega-Concepción *et al.*, 2017).

CO<sub>2</sub> lasers use a gas medium primarily composed of CO<sub>2</sub>. It emits in the far infrared spectrum, absorbed preferentially by hydroxyapatite and water in the mucosa and gingiva (Caprioglio, Olivi and Genovese, 2017). Its minimal scatter, rapid soft tissue vaporization, excellent water absorption, and negligible damage to surrounding tissue make them excellent lasers. Due to these properties, CO<sub>2</sub> lasers can be focused on the target tissue with precision and be used as scalpel type of lasers. They also produce a hemostatic cutting because vessels below 0.5 mm are coagulated (Green, Weiss and Stern, 2011).

Laser diodes are small, portable and economical surgical units that can be used for a multitude of operations on soft tissues (incision, excision, disinfection) and hard tissues (disinfection). These lasers have a broad wavelength range with good absorption in soft-tissue chromophores such as melanin and hemoglobin, providing excellent soft tissue incisions, coagulation and thermal ablation with antimicrobial activity (95-98% reduction of pathogenic bacteria). Research shows they can also be used in second stage surgery (Tunc *et al.*, 2019).

Nd:YAG lasers are composed of neodymium ions doping crystals of yttrium-aluminum-garnet. They are solid-state lasers whose wavelengths can vary between 1064 and 1320 nm. These lasers are minimally absorbed and can penetrate tissue to depths of up to 10 mm. They cause a great amount of tissue damage when compared with the CO<sub>2</sub> laser. Nd:YAG lasers are used for coagulation of angiomas, arthroscopic surgery of the temporomandibular joint (TMJ), and vascular tumor resections (Green, Weiss and Stern, 2011). A relative of Nd:YAG lasers are Nd:YAP where the crystals are composed

of yttrium-aluminum-perowskite. They are relatively newer than the Nd:YAG and have a wavelength of 1340nm which makes them more absorbed by soft tissues and thus, less penetrating. they can vaporize tissues while being highly hemostatic. They are used for hard dental tissues, soft tissues and dental canals (Gidel, 2017).

Erbium family lasers produce a wavelength of around 2940 nm (mid-infrared spectrum). Water and hydroxyapatite have an absorption peak at this wavelength making Er:YAG lasers most commonly used for restorative dental treatments. They are non contact instruments, have a selectivity for carious tissues which are richer in water and will reduce bacteria count in depth. They are also used in hard tissues for bone surgeries and in soft tissues rich in water. Their absorption is quick making them not very penetrating (Caprioglio, Olivi and Genovese, 2017; Gidel, 2017).

### **3. Different Laser Uses in Odontology**

Lasers can safely be used in adults as in children. Olivi *et al.* (2017) highlighted in their paper on pediatrics laser dentistry that laser can have advantages over classical therapy in patients, such as a better compliance with the treatment, and being usually less painful and scary.

Lasers in pediatric dentistry include uses in soft tissue surgery, prevention, detection and treatment of caries. They also provide a good adjunctive therapy in endodontics and pulpotomy in primary teeth, dental traumatology and overall patient comfort with the removal of vibrations (Martens, 2011). Frenectomy during or after orthodontic therapy, gingivectomy for patient affected by juvenile and aggressive periodontitis as well as decontamination are some examples of soft tissue laser application in children (Olivi *et al.*, 2017). However, these can also be done in adults requiring them. Pulpotomy of primary teeth, where the pulp chamber will be irradiated after extraction of the infected pulp, instead of formocresol pulpotomy, have shown good results. This irradiation accelerates wound healing, causes hemostasis, and has antimicrobial and cell stimulating properties, which are typical biostimulation effects (Ansari *et al.*, 2018). Other hard tissue uses of laser includes the preparation of the dentin priori to zirconia

crown bonding. Ulgey *et al.* (2020) evaluated the bonding strength of CAD/CAM-customized zirconia after treatment with different laser types. Application of the Nd:YAG laser was the most successful. In their study, Ramalho and his group (2014) used both high and low level lasers to get better results in esthetic dentistry; Nd:YAG for dentin decontamination, diode laser for soft tissue biostimulation around the treated tooth and Er:YAG laser for inner ceramic surface conditioning

For cavity treatments, Er:YAG lasers are capable of hard tissue ablation by vaporizing water and organic molecules selectively (Aoki *et al.*, 2015). In the case of enamel caries, Oliveira *et al.* (2018) showed that CO<sub>2</sub> lasers can be used conjointly with fluoride treatments in order to increase the microhardness and the remineralization the affected enamel. However further studies are needed to confirm this hypothesis as the isolated effect of fluoride treatment was not tested.

Another area that can benefit from the use of lasers is endodontics. The effect of different lasers to eliminate the bacteria from the root canal after classical preparation was described by Saydjari, Kuypers and Gutknecht (2016) work. Even though all the lasers used for decontamination worked in reducing bacteria count, the most efficient one could not be determined because the formulas for calculating the actual bactericidal effect widely differ. This decontamination effect is also very important in gingivitis and periodontal pockets treatment (Aoki *et al.*, 2015).

A different use for lasers in soft tissue is the stiffening of soft palate in response to a non-ablative CO<sub>2</sub> laser. These histopathological and biomechanical changes indicate irradiation at this wavelength can safely contract tissues in the upper airway to stiffen them over a long period of time. Since snoring is a vibration-dependent phenomenon, a concomitant reduction of snoring is expected. Clinical studies are needed to prove directly that this increase in stiffness can decrease the incidence of snoring in patients over such a time frame (Badreddine, Couitt and Kerbage, 2021).

Many lasers can be used for oral surgery such as CO<sub>2</sub>, erbium family lasers and Nd:YAG. Ortega-Concepción *et al.* (2017) showed that diode lasers were also effective

in the removal of oral soft tissue lesions. Precise cutting, adequate coagulation often removing the need for suture, pain reduction, decreased inflammation and potential complications, better repair and recovery, shorter treatment time, cost and easy application make it an excellent tool to remove small hyperplastic lesions like fibromas and exophytic lesions. This review found diode lasers to be superior to classical scalpel and hold numerous advantages compared to the other types of lasers too.

Lasers have been used to treat peri-implantitis and peri-implant mucositis both as a monotherapy or in combination with surgical or non-surgical therapy. The CO<sub>2</sub> laser is reported to be safer and able to enhance bone regeneration. The diode laser (980 nm) seems to be efficient in its bactericidal effect without changing the implant surface pattern. Er:YAG lasers exhibit a strong bactericidal effect against periodontopathic bacteria at a low energy level (Natto *et al.*, 2015; Lin, Suárez López Del Amo and Wang, 2018).

As a tool for disinfection, Dr Gérard Rey points out in his article: “*Action des lasers diode sur les Staphylococcus Auréus*” that even though many earlier studies showed the bactericidal power of lasers, clinical results were different and laser light alone was not enough. However, when used conjointly with oxygen peroxide, the coherent photons would create singlet oxygen which is a powerful germ killer allowing it to efficiently decontaminate periodontal tissues (LS - La Lettre de la Stomatologie, c. 2019).

Laser therapy is widely used in periodontics. Both high and low-level lasers can be used in surgical periodontal therapy - the first reduces the pain immediately after treatment while the former suppress significantly pain 2 to 7 days after the operation (Mikami *et al.*, 2020). A diode laser can be used both for the surgery and as an adjunct to surgical therapy, plus its bactericidal effect that was put in evidence by Gokhale *et al.* (2012). However other study showed that, while effective, diode laser therapy alone did not allow a faster resolution of gingival edema when compared to traditional therapy in gingivitis patients (Polizzi *et al.*, 2020).

#### **4. Laser-Assisted Biostimulation in Oro-Facial Tissues**

Light plays a role in our biology. The introduction of lasers as an amplified source of light gave us the opportunity to transfer this energy to the cell in order to stimulate its metabolic functions inducing pain relief, enhanced healing and tissue repair processes as well as reducing inflammation. The effect of biostimulation was discovered accidentally in the 1960s by Endre Mester into National Aeronautics and Space Administration (NASA) where researchers used it for enhancing the healing processes in space (Dompe *et al.*, 2020). They pointed out that laser application with low energy would result in lesion repair in mice. A low-level laser is a red light or infrared light whose wavelength has a low absorption power in water and is capable of penetrating into soft and hard tissues in a depth of 3mm to 15mm (Sobouti *et al.*, 2015). The underlying phenomenon causing biostimulation is not yet completely understood but it may be related to photochemical reactions within cells, rather than to thermal event. Therefore, low-level lasers are usually used to cause this effect, but the photo-thermal effect generated by high-level laser irradiation may have a positive influence on wound healing as one of biostimulation effects. Also, both can be used simultaneously (Aoki *et al.*, 2015).

Pain control following an operation is a necessary part of a treatment. Such pain results from tissue trauma and the release of inflammatory mediators. Several studies showed the reduction in pain after using photobiomodulation in different types of treatments; non-surgical and surgical periodontal therapy (Sanz-Moliner *et al.*, 2013; Rakhshan, 2019; Mikami *et al.*, 2020) and after a wide range of other surgeries not limited to the oral cavity (Ezzati, Fekrazad and Raoufi, 2019). As in neuropathic pain, which is a common, debilitating oro-facial disorder with a complex etiology that could be alleviated with LLLT (Holanda *et al.*, 2017). Madani *et al.* (2020) have compared LLLT with laser acupuncture therapy in the treatment of temporomandibular disorder which causes pain on the masticatory muscles. They found that both treatments were shown to be significantly effective. Low-level laser was suggested as a pain-control protocol because it has more advantages over oral pain relievers and drugs. This seems to be due to the fact that the pain control promoted by the laser overlaps with its ability to reduce inflammation and increase wound healing (Sobouti *et al.*, 2015).

Such wound healing seems to be another interesting application of laser irradiation. The additional decontamination and detoxification effect of laser therapy may already positively influence wound healing but this effect can be further amplified by a LLLT after the treatment (Aoki *et al.*, 2015). Two studies (Peplow, Chung and Baxter, 2010; Fekrazad *et al.*, 2016) investigated the effect of photobiomodulation on cultured cells and both found that laser irradiation can stimulate the proliferation of cells ultimately resulting in improved tissue repair, faster resolution of the inflammatory response, and a reduction in pain. Further studies are needed to determine the relevance and optimization of other key irradiation parameters. In periodontology, the adjunctive use of biostimulation accelerated palatal wound healing after free gingival graft procedures. For subepithelial connective gingival grafts and gingivectomies, photobiomodulation could promote wound healing post-surgery, but there was a lack of sufficient evidence. A decrease in post-operative pain was also noted (Lafzi *et al.*, 2019; Zhao, Hu and Zhao, 2021). An innovative technique called hemolasertherapy, was used in cases of interdental papilla loss associated with LLLT to stimulate the growth of gingival papilla in order to fill in the black spaces. Photobiomodulation in these clinical cases enables preservation, viability, and further differentiation, and stimulating the return of gingival stem cells. The results were considered excellent (Zanin *et al.*, 2018). It is worth noting that the rate of wound healing is strongly influenced by the degree of remaining collateral thermal injuries. Therefore, the actual photobiomodulation effect on wound healing during soft-tissue surgery is complicated and varies among lasers (Aoki *et al.*, 2015).

An exceedingly small part of the beam's energy will be converted into heat. Proper use of such heat presents little risk for tissue damage caused by increased temperature, yet this may be sufficient to induce vasodilation. Seraj *et al.* (2020) in a preliminary randomized clinical trial, found that this increase in micro-circulation could efficiently reduce the duration of anesthesia in pediatric patients.

The biostimulation described so far refers to soft tissue - however it also seems to exert effects on hard tissue. Bozkurt *et al.* (2017) evaluated the effect of laser irradiation on cementoblasts *in vitro*. The literature is controversial on the subject; a fact that can be

explained by the absence of studies with standardized procedures. However, the results indicated that biostimulation of cementoblasts might positively affect attachment gain after regenerative periodontal therapies since these cells participate in establishing the new periodontal attachment apparatus. Correlation have also been found between bone regeneration and LLLT. Meta-analysis made by Kheiri and collaborators showed the positive effect of photobiomodulation on osteogenesis and a certain relationship between dose and output power was found. New bone formation can be increased in early stage by applying LLLT through stimulating osteoblasts and fibroblasts proliferation. This effect would be more remarkable by combining with bone substitutes when treating bone defects caused by periodontitis (Zein, Selting and Benedicenti, 2017; Deana *et al.*, 2018; Kheiri *et al.*, 2020).

Thanks to the aforementioned properties, photobiomodulation can be used to help in the treatment and sometimes prevent the appearance of many oral pathologies such as: lichen planus, recurrent aphthous stomatitis, hyposalivation, pemphigus vulgaris, recurrent herpes simplex, burning mouth syndrome, bisphosphonate-related osteonecrosis of the jaw, trigeminal neuralgia, facial nerve paralysis, geographic tongue, and chronic sinusitis (Kalhori *et al.*, 2019). Gingival hyperplasia caused by gingivitis or as a consequence of an orthodontic or rehabilitation treatment can also be improved as it is caused by an inflammation of the surrounding tissues which low-level laser irradiation can soothe (Green, Weiss and Stern, 2011; Cardoso Bezerra *et al.*, 2015). Pain is one of orthodontic treatment most common side effect and the analgesic effect of LLLT could reduce it, in addition to potentially fasten the treatment thanks to the stimulation of osteoclasts and osteoblasts. This stimulation also proved to be effective when applied to peri-implant bones by enhancing osteointegration. The effects of photobiomodulation can also reinforce the efficiency of periodontal therapy (Aykol *et al.*, 2011; Gidel, 2017). Pamuk *et al.* (2017) also reached similar conclusion and added that it could be particularly interesting for smoking patients.

#### IV. DISCUSSION

Upon reading the published studies, lasers seem all so perfect. However, most of the studies already mentioned admitted more research was necessary. Indeed, some results presented were controversial while others did not follow the scientific method rigorously.

Oliveira *et al.* (2018) reported an increase in enamel hardness after enamel caries in all five tested groups: one only submitted to laser irradiation and four others combined laser treatment with fluoride application (in gel, mousse, acidulated or not). However, there was no control group that tested only the efficacy of fluoride application, meaning the results might be solely due to the use of the chemical.

Natto *et al.* (2015) wanted to compare the efficacy of different types of lasers to treat peri-implantitis. CO<sub>2</sub>, diode and erbium lasers showed good results. However, neodymium lasers were not tested on humans. Moreover, the studies presented limited sample size and short follow up period. Even though these treatments are promising, the absence of testing with neodymium lasers and the reduced number of patients did not allow a clear and unequivocal conclusion to be reached. The authors also referred that treatment could be more effective if used as an adjunctive tool to complement a bone graft, but more trials are required to test such hypothesis. It thus becomes clear that more well-designed studies are required.

Other studies found significant results with Er:YAG, CO<sub>2</sub> and diode lasers but failed with Nd:YAG, so only part of the information is available (Natto *et al.*, 2015; Lin, Suárez López Del Amo and Wang, 2018). Lin, Suárez López Del Amo and Wang, (2018) obtained significant results in the analysis of CO<sub>2</sub>, diode and Er:YAG as an adjunctive laser treatment of per-implant mucositis. These studies, on the other lasers, had no controlled evidence to support their evaluation. Thus, controversies have been reported in the literature and absence of long-term data available is required to assess the reduction of bleeding on probe after adjunctive laser therapy.

When considering biostimulation in particular, there are controversial results when using laser therapy. Mansouri *et al.* (2020) wished to sort out the literature on LLLT to determine its principal pros and cons. They found that low-level laser treatments have positive effects and only a few disadvantages in most studies. However, they found a lot of inconsistencies that could be attributed to a use of different parameters when testing and a lack of specific protocol when using a low-level laser in specific pathologies. They concluded that more research was needed although this type of therapy seems to be promising for the future.

Tissue regeneration using phototherapy alone has limited clinical evidence right now. It shows some promises, but extended studies are needed to better understand the mechanisms of tissue response at the molecular level. It seems to be promising for the improvement of periodontal and peri-implant treatments. It would be best used conjointly with debridement and decontamination along with other types of phototherapy (Aoki *et al.*, 2015).

Deana *et al.* (2018) reviewed the literature on the LLLT effect on osteoblast-like cells and found that they are indeed susceptible to photobiomodulation. However, there was a variation in the parameters considered among the studies. It was found that extremely high level of irradiance proved to be deleterious to cells. This is known as the *biphasic nature* of photobiomodulation.

Two studies evaluated the effect of photobiomodulation on stem cells and found that LLLT stimulated proliferation exhibiting positive effects in nearly all the tests. As results were dependent to laser parameters, the best parameters to use are not yet clearly identified for the different situations. This could be once again helpful in regenerative treatments but laser alone would not be enough (Peplow, Chung and Baxter, 2010; Fekrazad *et al.*, 2016).

The most important thing to remember from all these is that laser treatments and especially LLLT present mostly good results. However, more research and trials are needed to elucidate and strengthen some of the studies already published in order to

establish precise protocols and parameters to use in each different clinical situation. It should also be kept in mind that some of the articles were published a few years back.

Most of the articles refers the positive effect of laser usage compared to classical therapy alone in odontology. Only a few articles reported contraindications, main one being the fact that it is an expensive equipment that still requires a formation for the practitioner. On the other hand, laser therapy has almost no side effects (Gidel, 2017). It is a technology that could be widely used by well-trained practicing dentists willing to improve upon classical approaches.

It is possible to find in the literature some more therapeutic approaches by laser. Hemolasertherapy (Zanin *et al.*, 2018) combines photobiomodulation with the formation of blood drops to stimulate cell proliferation. The study revealed really good results but because it is an innovative technique, further studies will be needed to take advantage of it so that it can be used safely. Laser acupuncture resembles LLLT because it uses low light as well however the approach is different as laser acupuncture focuses its beam on acupuncture points. Madani *et al.* (2020) suggested that laser acupuncture could be used as an alternative to LLLT in treating temporomandibular disorders as he obtained effective results in less time. It should be noted that acupuncture points are still debated in the medicine field.

Lima, da Silva Sergio and de Souza da Fonseca (2020) investigated a new technic consisting of biostimulating via multiple wavelengths instead of one as seen in classical photobiomodulation. Superficial and deep tissues have different absorption coefficients so this protocol could be more effective. The results were positives, meaning that this could be a new approach to consider. Finally, some researchers investigated photobiomodulation using non coherent light with LEDs to stimulate stem cells proliferation. They found that if used alone it was able to stimulate proliferation of bone marrow stem cells but when used as an adjunctive tool with a graft it enhanced osteodifferentiation (Fekrazad *et al.*, 2016). These approaches could be considered alternatives to classical laser biostimulation.

## **V. CONCLUSION**

This paper hovered above the different uses of lasers in odontology and medicine in general to focus on biostimulation. Biostimulation is still a poorly understood process whose principal mechanism seems to be the stimulation of cell metabolism. This increased metabolism helps diminishing inflammation and thus pain and accelerate wound healing.

Lasers have various applications, from operative dentistry to surgery or endodontics. Biostimulation probably has the most uses in periodontics even though it can also be used to treat various oral pathologies.

Lasers can represent an advantage for a dental clinic providing better comfort for the patient, reducing post-operative and sometimes intra-operative inflammation and pain as well as improving the prognosis of many treatments. However, it should be remembered LLLT still needs more studies and trials to answer the remaining questions of its mechanism and the parameters and protocols that should be used.

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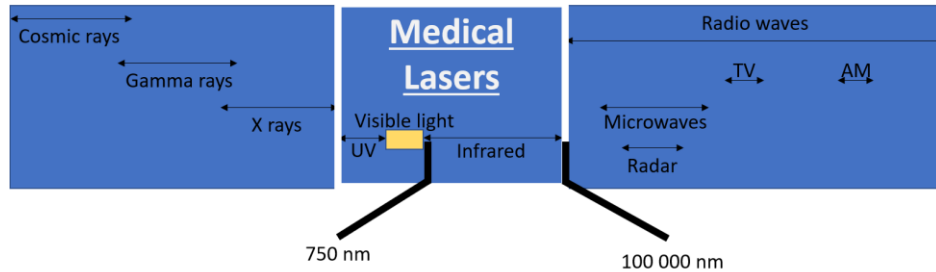
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## VII. ANNEXES

### Electromagnetic Spectrum



Lasers used in odontology are mostly found within the Infrared wavelengths.

Figure 1: Electro-magnetic waves spectrum and medical lasers spectrum. This picture is inspired from Dr Gérard Rey's work available at the following site: <https://journal-stomato-implanto.com/content/le-principe-du-laser-0>.

### Functionning of a LASER

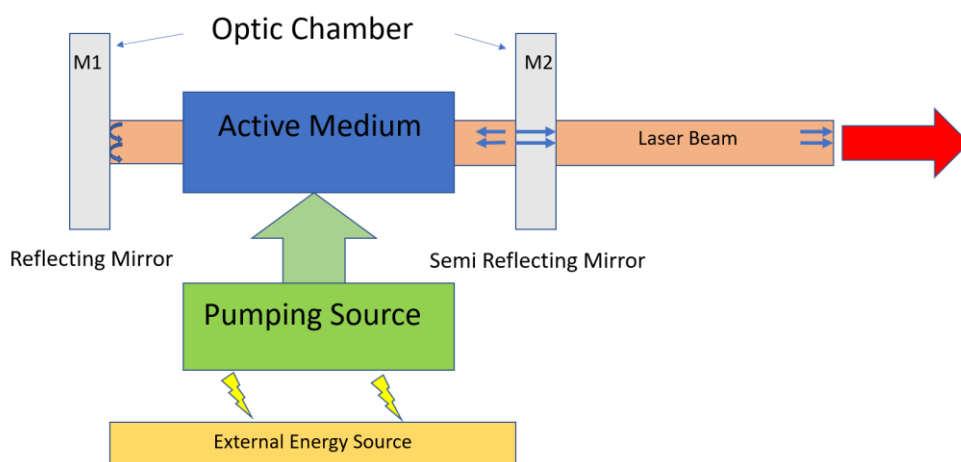


Figure 2: Basic representation of a laser's mechanism. This picture is inspired from Dr Gérard Rey's work available at the following site: <https://journal-stomato-implanto.com/content/le-principe-du-laser-0>.

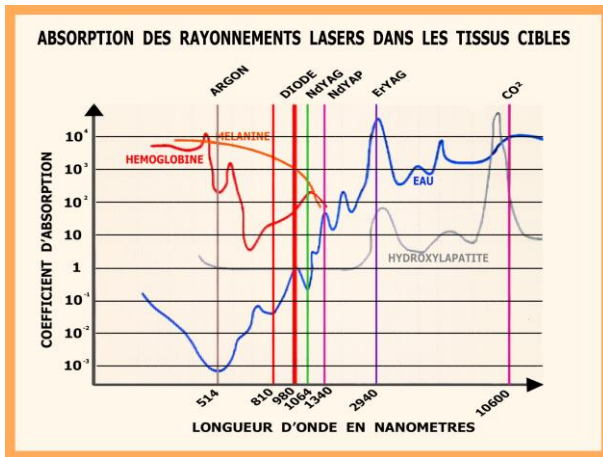


Figure 3: Graph showing the different absorption coefficients of target tissues in function of the wavelength used. This picture is a property of Dr Gérard Rey and is available at the following site: <https://journal-stomato-implanto.com/content/la-chirurgie-pre-implantaire-laser-assistee-quelle-longueur-d%E2%80%99onde-choisir>.

## Different Effects of LASERs on Target Tissues

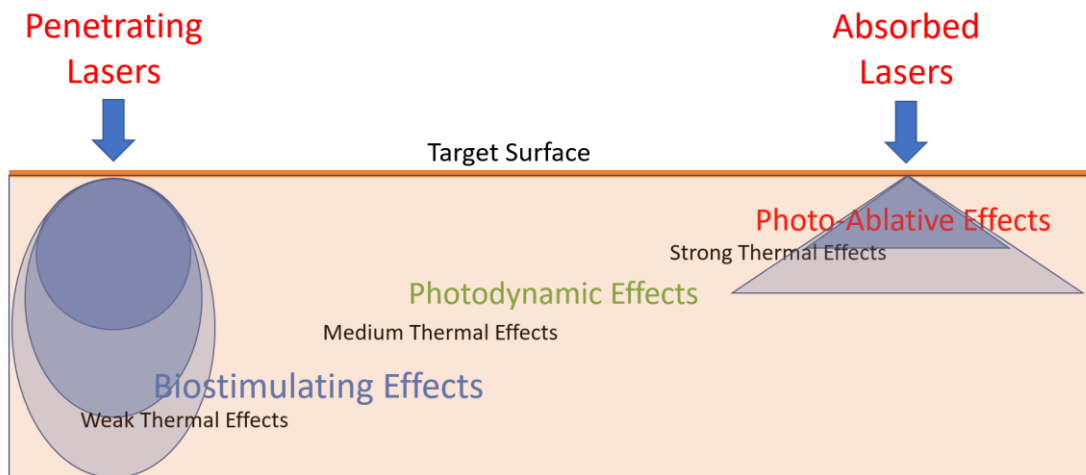


Figure 4: The principal effects of lasers on the tissues. This picture is inspired from Dr Gérard Rey's work available at the following site: <https://journal-stomato-implanto.com/content/le-principe-du-laser-0>.