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Abstract
To overcome the numerous limitations of curettes and ultrasound devices during periodontal therapy, many researchers have investigated the effects of lasers as an adjunct or alternative of conventional mechanical periodontal therapy. Lasers are one of the most promising modalities for non-surgical periodontal treatment, as they can achieve excellent tissue ablation with strong antimicrobial effects and root surface detoxification. Starting from the abovementioned, we set the main goal of this research - to present the benefits and advantages from dental lasers in periodontal treatment. This article presents an adequate literature review for the contemporary aspects of laser assisted periodontal therapy. All of the used literature data were published in peer-reviewed publications and journals. Most of the articles were in English language, published in the last ten years from 2013 until 2023. Various types of lasers can be used in periodontology, including Carbon Dioxide laser (CO2 laser), Neodymium: Yttrium Aluminum Garnet laser (Nd: YAG laser), Erbium: Yttrium Aluminum Garnet laser (Er: YAG) and Erbium Chromium: Yttrium Scandium Gallium Garnet laser (Er, Cr: YSGG). Most often, lasers containing the YAG group are more suitable in periodontology, due to their high absorption by water and hydroxyapatite, which is the highest compared to other wavelengths. Evidence shows that the laser provides better clinical and microbiological results compared to the use of hand instruments and sonic and ultrasound instruments and devices.
Keywords: dental lasers, periodontology, periodontal treatment, Er:YAG laser in periodontology.

INTRODUCTION

The numerous advantages of using laser light can hardly be ignored, such as precision, ease of usage and greater success in therapy compared to conventional therapy procedures. However, complete knowledge of this therapeutic tool is imperative to avoid side effects and obtain the full desired benefits. Laser interventions provide numerous benefits for patients such as: reduction of postoperative complications, shortening of the postoperative discomfort, less trauma during the performance of the interventions, and in most cases there is no need to use anesthetic agents.

Because on the variety of wavelengths available, the careful and highly skilled clinician must first determine the specific goals of the treatment before choosing the technology (whether laser will be used or not). Only in this way will it be possible to reach the desired end point/s in the course of the therapy procedure in the easiest, best and most efficient way.

Manual periodontal instruments have some advantages, such as better control over the instrument, a sense of touch that can easily recognize surface roughness, and obtaining a smooth surface. There are also several disadvantages such as the duration of the intervention, the need for a high degree of physical strength to remove the calculus, the presence of bleeding, which limits the visualization and access to the operating site, the presence of pain, the lack of accessibility to the distal regions, as well as difficulties in furcations treatment and subsequent roughness of the root surface. (Oda et al, 2004)

Compared to manual instruments, ultrasonic instruments leave more contaminated root cementum on the surface of the teeth after treatment, but still represent an ideal adjunct to the manual instrumentation of the tooth root surface. When ultrasound devices and instruments are used appropriately, postoperative discomfort for the patients is reduced. However, when use of ultrasound instruments there are also numerous disadvantages, apart from the release of contaminating aerosols, such as the possibility of potential injury to the structures of the teeth or surrounding parts, the formation of microcracks in the tooth enamel or on the surfaces of porcelain crowns and bridges, the creation of roughness on the surface, risk of interference in patients with cardiac pacemakers and leaving a softened layer after the treatment of periodontal pockets. (Wilson, 1958; Chen et al, 1994; Dibart et al, 2004)

Manual plaque removal and root planing and scaling are demanding procedures during non-surgical periodontal therapy. Therefore, more and more attention is directed towards the use of various instruments and devices that will increase the efficiency of periodontal therapy.

The need to use modern methods and techniques, which will minimize or completely exclude the appearance of the smear layer is bigger nowadays. One of those modern methods and techniques is the usage of the laser as an innovative tool and its effect on the root surface.

The main aim of this research was to describe the benefits and advantages of new therapeutic modality in periodontology-laser assisted periodontal therapy.

Adequate researched on PubMed for articles relevant to our topic- benefits from laser assisted periodontal treatement of studies activating limits like date range (1993-2026), the type of articles (Clinical Trial, Journal Article, Randomized Controlled Trial, Review, Comparative study) and English was chosen as the language.

BENEFITS FROM LASERS IN PERIODONTAL TREATMENT

The use of laser technology in dentistry dates back to the mid-eighties of the last century. In 1985, Myers and Myers published a paper describing in vivo removal of dental caries using a modified ophthalmic Nd: YAG laser. Four years later, it was proposed that the same Nd:YAG laser could be used for oral soft tissue surgery, ultimately representing the modern link between the use of lasers and clinical periodontology.

To overcome the numerous limitations of different periodontal instruments such as periodontal instruments and ultrasound devices during periodontal therapy, many researchers have investigated the effects of lasers as an adjunct or alternative to conventional mechanical periodontal therapy. Lasers are one of the most promising modalities for non-surgical periodontal treatment, as they can achieve excellent tissue ablation with strong antimicrobial effects and root surface detoxification.

Therefore, the question arises whether the application of laser light for treatment of periodontal pockets would result in a less rough surface and less chemical changes compared to the remaining methods of treatment of periodontal pockets. Also, the roughness of the resulting root surface, as well as the chemical changes that occur on it after the application of the laser light can vary to a large extent and depend on the type of laser (wavelength and power) as well as on the energy that is applied on the tissues.

Regarding the previously mentioned disadvantages of both hand instruments and ultrasound devices, their replacement with more appropriate and efficient methods has always been considered in modern dental practice. From here begins the application of lasers with different wavelengths to remove deposits from the root surfaces. It must be mentioned that various types of lasers can be used in periodontology, including the carbon dioxide laser (CO_2 laser), the neodymium yttrium aluminum garnet laser (Nd: YAG laser), the erbium yttrium aluminum garnet laser (Er: YAG) and erbium chromium: yttrium scandium gallium garnet laser (Er, Cr: YSGG). Most often, lasers containing the YAG group are more suitable in periodontology, due to their high absorption by water and hydroxyapatite, which is the highest compared to other wavelengths. Evidence shows that the laser provides better clinical and microbiological results compared to the use of manual instruments and sonic and ultrasound instruments and devices. (Derdilopoulou et al, 2007; Lopes et al, 2008; Hakki et al, 2010; Yaghini et al, 2015)

In the field of periodontology, the application of the Er: YAG laser for the treatment of periodontal hard tissue begins with studies by Japanese and German researchers. The following section presents data from numerous studies performed in vitro conditions, as well as clinical studies that demonstrated the effective application of the Er: YAG laser for the removal of supra and subgingival concrements and decontamination of the diseased root surface during periodontal non-surgical and surgical therapy procedures.

The Er: YAG laser is a laser that contains a medium in a solid aggregate state, it is a crystal laser that works in the infrared wavelength field (2,940 nm).

Stimulated emission of Er3+ ions in yttrium, aluminum and garnet crystals was first demonstrated back in 1975, paving the way to this, for that time, new type of laser - the Er:YAG laser. (Zharikov et al, 1975) Its emitted wavelength of 2940 nm that corresponds exactly to the maximum absorption in water, which is about 15 times higher than the absorption of the CO_2 laser and 20 000 times higher than that of the Nd: YAG laser. (Walsh & Cummings, 1994) Also, this type of laser light is well absorbed by hydroxyapatite, so it can be concluded that this type of laser is manufactured to effectively remove dentin and enamel, with only few and mild side effects, such as thermal damage to the dental pulp. (Bader & Krejci, 2006).

Due to its good absorption in water and hydroxyapatite, several studies have shown the efficiency of this laser in the ablation of hard and soft tissues and its bactericidal effects with less or no painful sensations in clinical application confirm the numerous advantages that this laser has. The variety of potential applications for this laser is being studied to this day and interest in its use in dental practice has increased among dental practitioners.

The latest scientific evidence indicates that the use of the Er: YAG laser in the treatment of chronic periodontal disease is equivalent to the mechanical treatment of periodontal pockets primarily in terms of reducing the depth of periodontal pockets determined clinically through the probing procedure and by reducing the bacterial population of subgingival dental plaque.(Padmanabhan, 2019) However, if achieving the clinical attachment level is considered as gold standard in non-surgical periodontal therapy, then the evidence supporting laser- assisted periodontal treatment over traditional therapy is minimal (at least). Today, in modern dental medicine, there is a growing number of publications that increasingly support the laser-assisted treatment method as a significant additional tool in achieving the desired effect of the therapy.(Jassim, 2019; Jaryal et al, 2021)

The main advantages of the Erbium laser family according to Schwarz et al. (2003) are the following:

- Higher absorption in water compared to carbon dioxide lasers, as well as compared to neodymium yttrium aluminum garnet (Nd: YAG) lasers.
- Good absorption in hydroxyapatite.
- Minimal thermal damage to the surrounding soft tissue and hard tissue structures, thus excluding numerous side effects that may occur.

What must be remembered is that when using the laser, the degree of damage is directly related to the increase in energy density delivered per unit area, and such thermal damage is graduated from simple surface cracking of the cement to complete cracking and melting with deep ablation of the cementum from the root surface of the tooth exposing the dentin.

Although the wavelength of light and its other physical characteristics determine the degree of energy absorption by the target tissue, the optical properties of the tissue must also be known. The optical properties of the tissue largely dictate the interaction with specific laser wavelengths. In this way, it will be possible to determine the desired effects that are needed during the therapeutic procedure, and of course to predict and prevent the side effects that may occur on the target tissue itself or in its environment.

For example, the optical properties of the tissues that make up the periodontium include numerous tissue factors such as pigmentation, water content, mineral content, heat capacity, which is affected by the thermal conductivity and density of the tissues and latent transformation changes (this group includes the processes of protein denaturation, water evaporation and mineral dissolution).

Each wavelength of laser energy is absorbed to a greater or lesser extent in water, pigment or hydroxyapatite, all of these chromatophores present in each part of the periodontal tissues. CO_2 laser whose wavelength is 10,600 nm has a high absorption coefficient in water and is therefore suitable for soft tissue surgery, but currently there is no scientifically proven clinical application for mineralized tissues. In contrast, the Nd: YAG laser with a wavelength of 1,064 nm and diode or semiconductor lasers whose wavelength ranges from 800 to 950 nm have lower absorption coefficients in water than CO_2 lasers, but are therefore better absorbed in pigmented tissues, while Er, Cr: YSGG lasers with a wavelength of 2780 nm and Er: YAG lasers with a wavelength of 2,940 nm are highly absorbed in both water and hydroxyapatite.

The basic physical characteristics, apart from the wavelength, which characterize the laser light, and are a function of the effects it will cause in the tissue, are the delivered energy in the tissue, power and energy density.

Energy as a characteristic of the output laser light is used only in pulsed lasers. In that case, the energy is described as the total energy contained in one pulse and is measured in joules (J). Its values can range from nanojoules (10^{-9}J) in microlasers to megajoules (10^{6}J) characteristic of macrolaser systems.

The effect that the laser light will cause in the tissues depends not only on the amount of energy delivered to the tissue, but also on the time for which it will be delivered in a certain volume or part of the tissue. The transmitted energy in a unit of time is expressed through the physical characteristic - power and is measured in watts (W).

Considering the entire possible interval of generated energies from 10^{-9}J to 10^{6}J and possible pulse durations from 10^{-15} s to 10^{-3} s, it is easy to say physically that laser devices can generate light with power in the range from the minimum few microwatts (10^{-6} W) to the maximum terawatts (10^{12} W).

In addition to the duration of the pulse, the duration between pulses also plays a significant role in the way energy is transmitted to the tissue. Therefore, each output signal is also characterized by a pulse repetition frequency. Frequency is expressed in Hertz, and is defined as the number of emitted pulses in one second. Depending on the methods of creating the pulse, the type of active medium, the pumping of electrons, etc., the repetition frequency of the pulses can be in the range of several Hz up to 109 Hz. With this in mind, in addition to the impulse power, an average power is also defined. In pulsed lasers, the mean power is the pulse energy multiplied by the pulse repetition frequency.

In contrast to the above, with lasers in continuous mode of operation, the output light energy is characterized by power (output energy in one second), while with lasers in pulsed mode of operation, the laser light is described through two reference values and that through the power on the impulse and through the mean power.

Apart from the numerous positive effects that lasers possess for the non-surgical therapy of periodontal disease, in addition, when lasers are used appropriately during periodontal therapy, they can have other benefits such as reduced bleeding, swelling and patient discomfort during the intervention. However, it must be mentioned that each laser has different wavelengths and power levels that can be safely used during different periodontal procedures. Damage to the periodontal tissues can only occur if an inappropriate wavelength or inadequate power level is used during therapy procedures.

The family of Erbium lasers which as mentioned includes Erbium:YAG (yttrium aluminum garnet) and Erbium,chromium:YSGG (yttrium scandium gallium garnet). Based on the wavelength, it can be noted that the Erbium: YAG laser belongs to the near-infrared part of the light spectrum, and it has been proven that, in addition to soft tissues, this laser is effective in the ablation of hard dental structures as well. (Paghdiwala, 1991; Lavu et al, 2015)

The surface modification of tooth root cementum has been studied using different laser wavelengths (CO2, Nd: YAG, Er: YAG and the diode laser). The main conceptual consideration in the biomodification of the root surface is the selection of an appropriate wavelength that will effectively remove the calculus, simultaneously preventing thermal damage to the dental pulp and unwanted removal of healthy tissue substance from the surface of the root itself. Achieving these goals requires a wavelength characterized by minimal penetration depth in mineralized tissues such as dental cementum.

The mineral phase of cementum and dentin in the human population is represented by oxidized hydroxyapatite which has intense absorption bands in the mid-infrared region. Consequently, if an examination of laser wavelengths is made, it can be concluded that the Er:YAG laser is the instrument of choice for effective calculus removal, for the creation of an adequate root surface and for the creation of a biocompatible surface for reattachment and proliferation of cells or tissues. (Aoki et al, 1994).

CONCLUSSION

Er:YAG and Er,Cr:YSGG lasers perform ablation of soft and hard tissues with minimal adverse effects on the surrounding tissues caused by heat. Erbium lasers are also effective in removing calculus and subgingival concrements and reducing the depth of periodontal pockets, root surface treatment, bone debridement, as well as in performing bone resective and regenerative surgery and probably they are considered the most suitable periodontal laser therapy. For these reasons, it is considered that this group of lasers will become an inevitable part of modern non-surgical periodontal therapy in the near future.

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