LASER ASSISTED PERIODONTAL TREATEMENT

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Abstract: In the last decades, dental lasers become a vital part of many dental practices and a solution to many periodontal problems that can be seen in everyday dental practice. Both manual and ultrasonic instruments for scaling and root planing have some shortcomings, their replacement by more appropriate and efficient methods has always been considered in modern dental practice and periodontolgy. This is where the application of LASERs with different wavelengths were inroduced for removing of deposits from the root surfaces. Various types of lasers can also be used in periodontology, including carbon dioxide laser (CO_2), neodymium yttrium aluminum garnet (Nd: YAG), Er: YAG and Erbium, Chromium: Yttrium Scandium Gallium Garnet (Er, Cr : YSGG). The main aim of this research is to describe a new therapeutic modality in periodontology- laser assisted periodontal therapy. We searched PubMed for articles relevant to our topic-laser assisted periodontal treatement of studies activating limits like date range (1991-2021), and the type of articles were Clinical Trial, Journal Article, Randomized Controlled Trial, Review, Comparative study and English was chosen as the language and humans as the species. Er: YAG laser is a laser that contains a solid state medium, it is a crystal laser that works in the field of infrared wavelength (2,940 nm). Due to its high absorption in water and hydroxyapatite, several studies have shown the effectiveness of this laser in the ablation of hard and soft tissues and its bactericidal effects with little or no pain in clinical application confirm the numerous advantages of this laser. Er: YAG laser is one of the most spectacular types of laser that can be used in periodontal therapy. Its effectiveness in removing the softened and pathologically altered parts from cement and in smoothing the root surface has been proven in numeorus in vitro studies. The latest scientific evidence suggests that the use of Nd: YAG or Er: YAG wavelengths in the treatment of chronic periodontal disease is equivalent to ustrasound and manual instrumentationof periodontal pockets primarily in terms of reducing the depth of periodontal pockets clinically determined through the probing procedure and by reducing the bacterial population of the dental plaque. However, if increasing of clinical attachment is considered as gold standard in non-surgical periodontal therapy, then the evidence supporting laser-assisted periodontal treatment over traditional therapy is not significant. Clinical parameters such as plaque indices, gingival indices, periodontal pocket depth, bleeding on probing and the occurrence of clinical attachment loss are further improved after treatment with the Er: YAG laser in relation to periodontal pocket mechanical debridman. It is also of interest to note that the use of laser light by the Er: YAG laser in the treatment of periodontal disease alone gives better results than the combination of manual and ultrasound therapy on the root surface of the tooth. The clinical efficacy of the Er: YAG laser is similar to that achieved after mechanical debridman of periodontal pockets. Because the Er: YAG laser has certain advantages, it can be expected to be an alternative choice in the treatment of chronic periodontitis.
Keywords: dental laser, laser-assisted periodontal treatement, Er:YAG laser, periodontal therapy

1. INTRODUCTION

The effectiveness of periodontal therapy is enabled by the exceptional healing capacity of periodontal tissues. During the initial periodontal treatment, mechanical debridement (scaling and root planing) is performed on the periodontally compromised root surface to eliminate all calcified deposits (subgingival deposits), as well as bacteria and their endotoxins from the cement to restore the biological compatibility of the root of the disease.
In the last ten years, dental lasers become a vital part of many dental practices and a solution to many periodontal problems that are seen in everyday dental practice. Dental lasers are very useful tool helping general practitioners and dental specialists for both soft and hard tissues. (Minovska et al, 2015)
Presence of an adequate amount of healthy and solid cement remaining after mechanical root canal treatment (scaling and root planing) should be beneficial for the healing of periodontal wounds, especially in terms of tissue attachment and regeneration. (Lindskog et al, 1987) A significant step towards successful periodontal regeneration, and thus towards successful periodontal therapy, can only be achieved if the surface contaminants (dental bacteria) can be removed with minimal damage to the cementum of the tooth root. In this regard, Erbium lasers are a significant and potential therapeutic tool for approaching the ideal periodontal treatment.

The use of laser technology in dental medicine dates back to the mid-1980s. In the year 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 suggested that the same Nd: YAG laser could be used for oral soft tissue surgery, which ultimately represented the modern link between the use of lasers and clinical periodontology. (David & Gupta, 2015)
Both manual and ultrasonic instruments for scaling and root planing have some shortcomings, their replacement by more appropriate and efficient methods has always been considered in modern dental practice and periodontolgy. This is where the application of LASERs with different wavelengths were inroduced for removing of deposits from the root surfaces. Various types of lasers can also be used in periodontology, including carbon dioxide laser (CO_2), neodymium yttrium aluminum garnet (Nd: YAG), Er: YAG and Erbium, Chromium: Yttrium Scandium Gallium Garnet (Er, Cr : YSGG). Most lasers of the YAG group are more suitable in periodontology because of their absorption by water and hydroxyapatite, which is the highest compared to other wavelengths. Evidence shows that the laser gives better clinical and microbiological results than those of the use of hand instruments and acoustic and ultrasonic instruments. (Lavu, 2015)
The main aim of this research is to describe a new therapeutic modality in periodontology-laser assisted periodontal therapy.
We searched PubMed for articles relevant to our topic-laser assisted periodontal treatement of studies activating limits like date range (1991-2021), the type of articles (Clinical Trial, Journal Article, Randomized Controlled Trial, Review, Comparative study), English was chosen as the language and humans as the species.

2. LASER ASSISTED PERIODONTAL THERAPY

Energy emitted by a laser is essentially monochromatic (of one wavelength). The photons comprising the energy beam are emitted as a coherent, unidirectional, monochromatic light that can be collimated into an intensely focused beam that exhibits little divergence. In the case of biologic tissues, the laser energy is absorbed by the target tissues and will only cause tissue side-effects in cases of deep tissue penetration. Variable parameters affecting energy absorption are emission wavelength, power (in watts), waveform (continuous or pulsed), pulse duration, energy/pulse, energy density, duration of exposure, peak power of pulse, angulation of the energy delivery tip to the target surface and optical properties of the tissue. (Wigdor et al, 1995)
Optical properties of tissues comprising the periodontium include factors as pigmentation, water content, mineral content, heat capacity that accounts for both thermal conductivity and tissue density, and latent heats of transformation (like denaturing of proteins, vaporization of water, and melting of mineral). (Bader, 2000) The optical properties of the tissue largely dictate the interaction with specific laser wavelengths. In that way it will be possible to determine the desired effects that are needed during the therapy procedure, and of course to assume and prevent the side effects that may occur on the target tissue or in its environment.
Each wavelength of laser energy is absorbed to a greater or lesser extent in water, pigment or hydroxyapatite, or chromatophores present in each part of the periodontal tissues. Thus, the CO_2 laser with a wavelength of 10,600 nm has a high water absorption coefficient and is therefore suitable for soft tissue surgery, but currently has no scientifically validated clinical application for mineralized tissues. In contrast, the Nd: YAG laser with a wavelength of 1,064 nm and diode or semiconductor lasers with a wavelength range of 800 to 950 nm have lower water absorption coefficients than CO_2 lasers, but are therefore better absorbs in pigmented tissues, while the Er, Cr: YSGG lasers with a wavelength of 2780 nm and the Er: YAG lasers with a wavelength of 2,940 nm are highly absorbed in both water and hydroxyapatite. (Hakki et al, 2010)
The presence of certain restrictions and shortcommings of the scaling and root planing, such as difficult access to deep pockets and friction, has led to the development of new therapeutic strategies. Er: YAG laser is one of the most spectacular types of laser that can be used in periodontal therapy. Its effectiveness in removing of the softened and pathologically altered dental cement and in smoothing the root surface has been proven in vitro. However, the clinical efficacy of the Er: YAG laser remains controversial. (Schwarz F et al, 2003).
The latest scientific evidence suggests that the use of Nd: YAG or Er: YAG wavelengths in the treatment of chronic periodontal disease is equivalent to ustrasound and manual instrumentationof periodontal pockets primarily in terms of reducing the depth of periodontal pockets clinically determined through the probing and by reducing the bacterial population of the dental plaque. However, if increasing of clinical attachment is considered the gold standard in non-surgical periodontal therapy, then the evidence supporting laser-assisted periodontal treatment over traditional therapy is not significant. Nowadays, there is a growing number of papers in modern dental medicine that increasingly support the laser-assisted type of treatment as a significant complementary tool in achieving the desired effect of therapy. (Yaghini, 2015)
The Erbium family of lasers, which includes erbium YAG (yttrium aluminum garnet) and Erbium chromium YSGG (yttrium scandium gallium garnet), are solid lasers in which yttrium garnet crystals are alloyed with aluminum or

scandium and gallium. The wavelength of the Erbium: YAG lasers is 2940 nm, while the wavelength of the Er: Cr YSGG lasers is 2780 nm. Based on the wavelength, it can be noticed that the Erbium: YAG laser belongs to the part of the infrared spectrum of light and has been proven to be effective in the ablation of dental hard tooth structures. (Paghdiwala ,1998) Due to its high absorption in water and hydroxyapatite, several studies have shown the effectiveness of this laser in the ablation of hard and soft tissues and its bactericidal effects with little or no pain in clinical application confirm the numerous advantages of this laser. 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 dentists. (Derdilopoulou et al, 2007) It emitted wavelength of 2940 nm and 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. Also this type of laser light is well absorbed in hydroxyapatite, so it can be concluded that this type of laser is manufactured for effective removal of dentin and enamel, with only minor and minor side effects, such as thermal damage to the tooth pulp. (Zharikov et al, 1975) For minimally invasive dentistry with the Er: YAG laser as an alternative, an output power of 10-12 W is considered as sufficient. (Lukac et al, 2004)

The surface modification of the tooth root cement has been studied using different laser wavelengths, but primarily with CO_2, Nd: YAG, Er: YAG and 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, while preventing thermal damage to the tooth pulp tissue and unwanted removal of the healthy structure of the root surface. Achieving these goals requires a wavelength that is characterized by a minimum depth of penetration into mineralized tissues such as tooth cement. (Theodoro et al,2003)

Clinical parameters such as plaque indices, gingival indices, periodontal pocket depth, bleeding on probing, and the occurrence of clinical attachment loss are further improved after treatment with the Er: YAG laser in relation to periodontal pocket mechanical debridman. It is also interesting to note that the use of laser light by the Er: YAG laser in the treatment of periodontal disease alone gives better results than the combination of manual and ultrasound therapy on the root surface of the tooth. (Schwarz et al, 2003)

One follow-up study of periodontal treatement over a period of two years showed significantly better long-term positive effect on root surface with the Er: YAG laser alone than manual instrumentation of periodontal pockets. The results regarding the improvement of the clinical attachment loss compared to the beginning were 28.5% after one year of Er: YAG laser treatment in terms of mechanical instrumentation of the periodontal pockets where the improvement was find in 13.8% of the subjects after the first year. After two years, there was still an improvement in 22.2% of the subjects who were treated with laser as opposed to only 10.7% who were treated with classical methods of periodontal therapy. The clinical improvement of attachment loss after the use of the Er: YAG laser in the treatment of periodontal disease is twice as large as the use of planing and root scaling. (Schwarz et al, 2004)

According to the results presented by Frentzen et al., (2002) clinically and histologically, scaling and rooth planing of the periodontal pockets resulted in complete debridement of all surfaces of the subjects, creating a smooth root surface. At the sites where the laser was used, the laser treatment, according to the authors, showed greater tissue removal and the creation of a rough surface. Hence, they concluded that laser treatment of periodontal pockets with the help of the Er: YAG laser results in increased loss of cement and dentin, which should be taken into concideation in different clinical situations.

It should be noted that several in vitro studies have shown morphological changes on the root surface due to thermal action induced by heat induced by the Nd: YAG laser. As with the CO_2 laser, changes on the root surface occur when using the Nd: YAG laser, which include the appearance of craters, grinding and melting, and re-hardening of the mineral phase on the root surface. However, it should be noted that even the lowest energy density used in these studies was still higher than currently recommended for in vivo use. Hence, it can be noted that such studies have no clinical significance, but are a good basis for further consideration in modern dental science.(Ting et al, 2007; de Oliveira, 2015; Sasaki et al, 2002)

The characteristic microstructure of the root surface after the use of the Er: YAG laser tends to make adequate enviroment for early settlement of periodontal cells. However, the combination of mechanical treatment of root surfaces by manual and ultrasonic instrument can improve and increase the biocompatibility of Er: YAG laser treated root cement by removing changes in surface microstructures and further creating collagen fibers.(Maruyama et al, 2008) Er: YAG laser is also bactericidal. According to a study conducted at the end of the last century, the survival rates of highly persistent resistant bacteria in P. gingivalis colonies decreased significantly with energy levels from 7.1 to 10.6 J / cm2. These findings suggest that the Er: YAG laser has high bactericidal potential even at low energy levels.(Ando et al, 1996) Fuji et al. in 1998 evaluate the effects of Er: YAG laser radiation on the cement root surface using scanning electron microscopy (SEM). Samples were obtained from extracted human periodontically diseased teeth. Er:YAG laser beam is then applied with varying powers ranging from 25 to 100 mJ / pulse / sec. Observations of the root surface showed a relatively flat surface in specimens without periodontal infection. In samples exposed to Er: YAG laser radiation, the laser beam created a circular crater defects on the surface of the tooth roots. Lesions showed an irregular and sharp contact surface. SEM observations of these specimens showed a layer of damaged tissue, especially on the examined cement surfaces that had been treated with laser light. (Fuji et al, 1998)

Gašpirc & Skalerič (2001) made a comparison of morphology, chemical structure and diffusion through solid tooth tissues after the use of Er: YAG and Nd: YAG lasers. This study showed that the Er: YAG laser only affects the morphology and diffusion processes of root surfaces, while the Nd: YAG laser also alters the chemical structure of root proteins.

A comparative study compares the surface of tooth roots after application of Er: YAG laser radiation, compared to CO_2 laser radiation and untreated surfaces, using Fourier Transformed Infrared (FTIR) spectroscopy. The surfaces were smooth after irradiation by the Er: YAG laser with cooling water, were burnt and irregular after irradiation by the Er: YAG laser without cooling water, and completely carbonized by CO2 laser irradiation. The FTIR profiles from surface samples treated with the Er: YAG laser with cooling water were similar to those from untreated samples, except for a slight reduction in OH and amide groups, mainly related to organic components. Results also showed that these laser treatments selectively abdicate more organic components than inorganic components and that Er: YAG laser irradiation with water-coolant does not cause major compositional changes or chemically harmful changes in any part of the root whether it is cement or dentin.(Sasaki et al, 2002)

According to Yamaguchi et al.,(1997) the use of the Er: YAG laser can remove 83.1% of the lipopolysaccharides present on the root surface. This study suggests that Er: YAG laser radiation may be useful for modifying the root surface in periodontal therapy. The clinical efficacy of the Er: YAG laser was similar to that achieved after mechanical debridman of periodontal pockets over a three-month postoperative period. The clinical benefits of the Er: YAG laser as an adjunct method to mechanical treatment of periodontal pockets during periodontal therapy were still lacking. Because the Er: YAG laser has certain advantages, it can be expected to be an alternative choice in the treatment of chronic periodontitis. (Zhao et al, 2014) Delayed healing of Nd:YAG laser wounds compared to scalpel incisions also has been reported by Romanos et al.(1995) but only when using 3 W of power and a 20-Hz pulse rate. Healing was equivalent for scalpel and Nd: YAG wounds when the laser was used at a lower power setting of 1.75 W and 20 Hz.

Er:YAG laser would appear to be the instrument of choice for effective removal of calculus, for root etching, and for creation of a biocompatible surface for cell or tissue reattachment. This latter statement is supported by Aoki et al.(2004) in their definitive review of the literature concerning laser applications in nonsurgical periodontal therapy.

3. CONCLUSION

The main advantages of laser-assisted peridontal treatement, esspecually of Erbium laser family are higher water absorption compared to carbon dioxide lasers as well as neodymium yttrium aluminum garnet (Nd: YAG) lasers and good absorption in hydroxyapatite. They made minimal thermal damage to the surrounding soft-tissue and hard-tissue structures, which excludes the numerous side effects that may occur. The clinical efficacy of the Er: YAG laser was similar to that achieved after mechanical debridman of periodontal pockets. Because the Er: YAG laser has certain advantages, it can be expected to be an alternative choice in the treatment of chronic periodontitis.

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