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Lasers in the Treatment of Dentin Hypersensitivity: A Review

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ABSTRACT
Dentin hypersensitivity (DH) is a relatively common painful condition among dental problems for which several treatment options have been tested. Although many studies have been performed regarding the diagnosis and treatment of DH, dental professionals are still confused about the definite diagnosis and treatment. The use of lasers as a treatment for dentin hypersensitivity was first introduced in 1985. Laser has been investigated as one of the possible therapies to minimize pain by either obliterating dentinal tubules or promoting dental analgesia. Laser treatment in dentin hypersensitivity is an interesting and controversial issue and many investigations have been done on its mechanism of action, advantages, and disadvantages. The purpose of this overview is to summarise our current knowledge regarding laser applications for the treatment of dentine hypersensitivity.

Keywords-*dentine hypersensitivity; laser therapies; review ; dentinal tubules ; desensitizing.*

Introduction

Dentine hypersensitivity is characterized by short, sharp pain arising from exposed dentine in response to stimuli typically thermal, evaporative, tactile, osmotic or chemical and which cannot be ascribed to any other form of dental defect or pathology.[1] Since the ruby laser was developed by Maiman (1960), researchers have investigated laser applications in dentistry.

Laser is a device which transforms light of various frequencies into a chromatic radiation in the visible, infrared, and ultraviolet regions with all the waves in phase capable of mobilizing immense heat and power when focused at close range. The word ''laser'' is an acronym derived from Light Amplification by the Stimulated Emission of Radiation. After initial experiments with the ruby laser, clinicians began using other lasers, such as argon (Ar), carbon dioxide (CO2), neodymium:yttrium-aluminum-garnet (Nd:YAG), and erbium (Er):YAG lasers. The first laser used for the treatment of dentine hypersensitivity was reported by Matsumoto et al. using Nd:YAG laser.[2]

The lasers used for the treatment of dentine hypersensitivity are divided into two groups:

1- Low output power (low-level) lasers:Helium-neon (He-Ne) and gallium-aluminum arsenide (GaAlAs)(diode) lasers.

2- Middle output power lasers: Carbon dioxide laser (CO2), neodymium- or erbium-doped yttrium-aluminum garnet (Nd:YAG, Er:YAG lasers) and erbium, chromium doped: yttrium, scandium, gallium and garnet (Er,Cr:YSGG) lasers.[3,4]

Desensitization seems to depend mostly on the type of laser therapy adopted. [5] The mechanism causing a reduction in hypersensitivity is most unknown but is thought that the mechanism for each laser is different. In case oflow output power lasers, a small fraction of the lasers energy is transmitted through enamel or dentin to reach the pulp tissue. [6] Low-power laser therapy is an appropriate treatment strategy to promote biomodulatory effects, minimize pain and reduce inflammatory processes. Its use has been widely accepted and approved due to satisfactory results reported in the literature. In contrast, the effects of middle output-power lasers, such as the carbon dioxide, Nd:YAG, Er:YAG and Er,Cr:YSGG lasers, are relatedto an increase in surface temperature which can result in the complete closure of dentinal tubules after recrystallization of the dentinal surface. [5]

MECHANISM OF LASER TREATMENT

The mechanisms involved in laser treatment of dentine hypersensitivity are relatively unknown.[3] The laser, by interacting with the tissue, causes different tissue reactions, according to its active medium, wavelength and power density and to the optical properties of the target tissue. [7] In order for a laser to actually alter the dentin surface, it has to melt and re-solidify the surface. This effectively closes the dentinal tubules. This does not occur. It is felt that laser treatment reduces sensitivity by coagulation ofprotein without altering the surface of the dentin.[8]

Pashley, suggested that it may occur through coagulation and protein precipitation of the plasma in the dentinal fluid or by alteration of the nerve fiber activity.[9]

The study by McCarthy et al.indicates that the reduction in DH could be the result of alteration of the root dentinal surface, physically occluding the dentinal tubules. [10]

According to Myers & McDaniel’s study laser energy interferes with the sodium pump mechanism, changes the cell membrane permeability and/or temporarily alters the endings of the sensory axons .[3]

The immediate analgesic effect in the treatment of dentine hypersensitivity with diode laser was reported by Brugnera Júnior et al. Based on this study the laser interaction with the dental pulp causes a photobiomodulating effect, increasing the cellular metabolic activity of the odontoblasts and obliterating the dentinal tubules with the intensification of tertiary dentine production.[11]

Low Output Power Lasers

He-Ne laser: The first use of He-Ne laser for the treatment of dentine hypersensitivity was reported by Senda et al. (1985), then, consecutively by several other investigators. [12] Irradiation modes : pulsed (5 Hz only) and continuous wave (CW) mode have been used. The laser tip has to be placed as close as possible to the tooth surface in non-contact mode. According to physiological experiments, He-Ne laser irradiation does not affect peripheral A-delta or C-fiber nociceptors, but does affect electric activity. Treatment effectiveness rates of He-Ne laser ranges from 5.2%–100% based on different studies. [3,4,7]

GaAlAs laser: The first use of this laser in dentin hypersensitivity treatment was reported by Matsumoto et al. and later by others.[13]Three wavelengths (780, 830, and 900 nm) of GaAlAs have been used for the treatment of dentine hypersensitivity.[3] The laser tip has to be placed as close as possible to the tooth surface in noncontact mode. It is assumed that this type of low output power lasers mediates an analgesic effect related to depressed nerve transmission. According to physiological experiments using the GaAlAs laser at 830 nm, this effect is caused by blocking the depolarization of C-fiber afferents.[4,7] Treatment effectiveness rates range from 53.3%–94.2% for the GaAlAs laser at 1-month follow-up.[3]

Middle Output Power Lasers

CO2 laser: This laser was first used for the treatment of dentine hypersensitivity by Moritz et al. (1996). [14] Output powers of 1 to 2 W with CW or pulse mode can be recommended. Sometimes an air blast should be used for preventing the tooth pain induced with the laser irradiation. The laser tip has to be kept on the tooth or gingival surface at a distance of 10 to 20 cm and has to be scanned as quickly as possible on the tooth or gingival surface in order to avoid thermal damage to the tooth or gingival surface. [4] Treatment effectiveness ranges from 59.8 to 100%. CO2 laser effects on dentin hypersensitivity are due to the occlusion or narrowing of dentinal tubules. There have been no reports on nerve analgesia by CO2 laser irradiation. Using the CO2 laser at moderate energy, mainly sealing of dentinal tubules is achieved, as well as a reduction of permeability.[3,4]

Nd:YAG laser: The first use of this laser for the treatment of dentine hypersensitivity was reported by Matsumoto et al. (1985).[2] A power output from 0.3 to 2 W is usually used. Continuous or pulsed wavelength is used and the number of the pulses is from 10 to 20 Hz. [3,4] When using Nd:YAG laser irradiation, the use of black ink as an absorption enhancer is recommended, to prevent deep penetration of the Nd:YAG laser beam through the enamel and dentin and excessive effects in the pulp. Without Chinese black ink, the laser tip has to be held over the tooth surface at a distance of approximately 10 to 20 cm. When Chinese black ink is used, the laser tip has to be kept close to the tooth or gingival surface in noncontact mode, and has to be scanned as quickly as possible over the tooth or gingival surface in order to avoid thermal damage to the tooth or gingival surface.[4] Treatment effectivenessranged from 5.2 to 100%. The mechanism of Nd:YAG laser effects on dentine hypersensitivity is thought to be the laser-induced occlusion or narrowing of dentinal tubules as well as direct nerve analgesia.[15,16,17] Nd:YAG and CO2 lasers effectively cause occlusion of dentinal tubules .[3,4]

Er:YAG laser: This type of laser is suitable for caries treatment but endodontic and periodontic applications have also been studied. It was first used for DH therapy by Schwarz et al. [18] The parameters of Er:YAG laser irradiation for DH therapy are 1 W and 10-12 Hz for less than 60 s. In order to prevent damage to the tooth and gingival surface, the distance ofthe laser tip to tooth surface has to be kept more than 10 cm. The laser tip has to be quickly scanned across the tooth or gingival surface to prevent laser damage on the tooth or gingival surface.[4] The reduction in DH at 6 months with the Er:YAG laser reportedly ranges from 38.2%–47%.

However there are a lot of ambiguous points in mechanism of Er:YAG as this laser is absorbed by hydroxyapatite’s water molecules, which can cause dentin surface ablation and is opposite to the sealing of the dentinal tubules.[19]

According to Kimura, Nd:YAG laser is more effective than Er:YAG laser.[4]

Er,Cr:YSGG lasers: The Er,Cr:YSGG laser has been shown to be effective for soft-tissue surgery as well as for cutting enamel, dentine and bone. However, there is limited knowledge on the effects of this laser on DH and few studies have been published concerning the clinical aspects of the desensitizing effect obtained with the Er,Cr:YSGG laser. The output power used for DH therapy varies from 0.25 to 0.5 W. [5]

Yilmaz et al. demonstrated that the single application of Er,Cr:YSGG laser has shown efficacy in rapid DH reduction compared with placebo treatment. This effect has become apparent immediately, and it remained stable for a 3-month examination period.[20]

Based on the results of a Short-term clinical evaluation which compared the effects of Er:YAG and Er,Cr:YSGG lasers on DH, the Er,Cr:YSGG laser at a power of 0.25 W showed the best performance in the clinical evaluations. [5]

COMBINATION OF LASER TREATMENT WITH FLUORIDES

There have been some reports on combination use of laser irradiation with chemical agents. The combination use of laser irradiation with chemical agents such as sodium fluoride and stannous fluoride can enhance treatment effectiveness by more than 20% over that of laser treatment alone. [21,22,23]

The combined use of the GaAlAs laser (830 nm wavelength) with fluoridation enhances treatment effectiveness by more than 20% over that of laser treatment only.[21]

In an in vitro study, most dentinal tubule orifices were occluded after treatment by Nd:YAG laser irradiation followed by topical sodium fluoride.[23]

Hsu et al. evaluated the combined occluding effects of fluoride-containing dentin desensitizer and Nd-YAG laser irradiation on human dentinal tubules. The occluding agent was thus *burned into* the dentinal tubules, and could neither be dissolved by vitamin C solution nor removed by brushing. Therefore, they concluded that the FDTOA combined with Nd-YAG laser irradiation burns the occluding agent into the dentinal tubules increasing the duration of desensitizing effect.[24]

Goharkhay et al., reported that CO2 laser irradiation through a layer of stannous fluoride causes a highly resistant layer on sensitized dentin. This layer induced by physical and chemical bonding mechanisms, provides a superior defense against external stimuli.[25]

CONCLUSION

Dentinal hypersensitivity is a problem that plagues many dental patients. When a patient presents with dentinal hypersensitivity symptoms, they should be examined and informed ofthe multiple treatment options that may be necessary to eliminate the problem. The patient should be responsible for the decision making process since some of their daily habits may be contributing to the problem and if not changed the condition will persist. Since dentine hypersensitivity has multifactorial etiology and generally more than one factor is found associated and active in this painful manifestation; therefore, more than one treatment method should be associated to desensitize the dentine to satisfactory levels. A combination oflaser therapy and topical desensitizing factors, can increase the success of the treatment compared with either treatments alone.

With the development of laser technology, laser applications in dentistry will increase. Since laser devices are still relatively costly, access to them is limited. To date, four kinds of lasers have been used for the treatment of dentine hypersensitivity, but other lasers also have potential for this application. Ideally, the laser in the future will have the ability to produce a multitude of wavelengths and pulsewidths, each specific to a particular application. The mechanism involved in laser treatment of dentine hypersensitivity are relatively unknown. Once this knowledge is established, the potential for developing lasers for the treatment of hypersensitivity can be fully explored and realised.

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