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Prevention of Enamel Caries by Low Power Dye Assisted He-Ne Laser: an In Vitro Study

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Abstract

The objective of this study aimed to assess the carieslike lesion preventive potential of low power dye assisted He-Ne laser.

Enamel of extracted human premolar teeth were painted with methylene blue dye and irradiated with 5 mW of He-Ne laser, which emitted laser with 632.8 nm in wavelength. Another group were irradiated without dye application, and the third group was served as control (without laser irradiation). All samples were subjected to carieslike lesion formation by 3.5 pH lactic acid for 21 days. The crowns after that were sectioned into ground cross sections and the lesion depths were measured under a polarizing microscope.

According to this study, successful carieslike lesion inhibition could be achieved to 29% extent, by using low power dye assisted He-Ne laser irradiation.

Keywords: Enamel, Caries, He-Ne, Laser, Dye

Introduction

Almost immediately after the development of the first laser in 1960, researchers began looking at its possibilities in dental treatment. Most of the early research explored the effects of laser on enamel, dentin and pulpal tissue [(1)]. Since then, lasers have been studied for use in oral and maxillofacial surgery, periodontics, preventive dentistry, endodontics, diagnosis and fixed prosthodontics. With the development of laser with flexible fiber delivery systems, the accuracy and usefulness of lasers in dentistry have been enhanced. Most commonly used in dentistry today are the carbon dioxide, or CO_2, laser; the argon laser; and the neodymium: yttrium-aluminum-garnet, or Nd:YAG, laser.

One potential application of dental lasers is as a preventive laser treatment of dental hard tissues to increase their resistance to caries [(2-4)].

The initial limitations for the laser's clinical use were based on some unanswered questions concerning the safety of laser irradiation of hard tissue. Effects on hard tissue depend on the type of laser used, as well as the exposure time. Temperature changes can be rather large, although they are influenced by the absorption properties of enamel and dentin.

These findings, have established beyond doubt the potential of laser to enhance caries resistance. Comparative investigations of the various

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wavelengths used are needed to determine the optimum operating regimens to maximize benefit and minimize side effects.

However, promising results have been reported about the potential use of dyes to enhance tissue absorption in the near-infrared range for several medical applications [5,6].

Photoactivated dye techniques have been developed which use low power lasers to elicit a photochemical reaction. Photoactivated dye techniques can be used to disinfect of peri-implantitis [7,8].

The use of an applied dye to enhance laser energy absorption in tissue is helpful in confining energy penetration to a small volume, while reducing the total laser power required for treatment. In this study, the topical application of the photo-absorbing dye methylene blue to enamel surface, in conjunction with He-Ne laser radiation, allows localized energy deposition. This dye exhibits a strong absorption between 600-650 nm [9]. The risk of thermal damage to the surrounding hard and soft tissues is reduced since they absorb light in this wavelength region poorly.

Materials and Methods

An experimental design was used to asses the inhibitory potential of caries preventive laser treatment. First, the caries preventive treatment was applied to caries free enamel surface. Then the teeth were subjected to an artificial carieslike challenge. Finely the carieslike lesions depths were measured and compared with carieslike lesions in control teeth.

A total of 30 newly erupted human premolars extracted for orthodontic purposes were selected for this in vitro study. The teeth were cleaned from soft tissues and polished with fluoride-free prophylaxis. To ensure that they are caries-free, the teeth were examined under reflected light microscope (Baush & Lomp). The surface of each tooth was covered with acid-resistant varnish (QD England), leaving two windows of approximately (2) mm in diameter on the buccal surface.

The teeth were divided into 3 groups of 10. Two groups (I and II) were used for experimental laser irradiation, and the third group was the control group.

Methylene blue dye (MK 115 Japan) was applied to the enamel surface of group I (on the buccal and lingual windows). Both groups (I and II) were subjected to laser irradiation.

The samples were irradiated using continuous wave He-Ne laser supplied with Blitz 50 sv system (asa medical laser). He-Ne laser emits CW irradiation with 632.8 nm wavelength.

The used laser parameters in this study were 0.05W for 60 seconds. The calculated power density on each samples 64 mW/cm^2.

Carieslike lesions were created on all teeth by immersing then in (pH 3.5) lactic acid (Fluka AG Switzerland) at 37ºC.

Following 21 days of incubation, cross sections were applied to the samples to prepare microscopical slides.

These microscopical slides were examined under polarizing microscope (Zeiss Germany). Lesion depths were measured using a graticule supplied with the polarizing microscope.

The measured lesion depths included the surface zone and the body of the lesion.

ANOVA (single factor) statistical analysis was applied to the result.

The caries inhibition percentages of the experimental samples were estimated using the formula:

(average lesion depth of experimental samples - average lesion depth of control samples) * 100 %

average lesion depth of experimental samples

Results

One way analysis of variance showed that there were significant difference between the irradiated groups (I and II) and the control group (Table-1).

Table-2 gives average lesion depths and caries inhibition percents of group I , II and control group.

The average lesion depths of group I were lower, to a statistically significant extent, than the values found in group II and control group. However, that was not true between group II and control group.

The inhibition percent of carieslike lesions in group I reached to 29%. In group II it was less than 2%.

Discussion

The dye-assisted carieslike inhibition of He-Ne laser in this study represents more promising findings. He-Ne laser has very low power as compared with other lasers used for caries prevention. By using methylene blue dye as an absorbent on the irradiated area, there is significantly more carieslike inhibition reached to 29%.

Several early researchers described the potential of laser in caries prevention. Since the first description of their use in this field, nearly all the common laser wavelengths have been considered, because each laser wavelength have its own physical properties and absorption mechanisms, resulting in unique characteristics of tissue interaction and biological effects.

CO_2 and Nd:YAG laser are the most common type used by researcher and clinician in dentistry. About 30% caries inhibition was achieved by using Nd:YAG laser [10].

Other studies used CO_2 laser to produce a better effects using 3, 4 watts power [11,12].

Advancement in laser technology was achieved by the use of Er:YAG laser, which appeared to hold some promise for hard tissue treatment. The use of Er:YAG laser on enamel seemed to be an effective tool for caries prevention [13]. By using argon laser for bonding orthodontic brackets, there is 22% caries reduction in lesion depths within irradiated area [14].

In an attempt to produce that desired effect of caries inhibition by using low power irradiation, diode laser was used successfully in recent research [15].

The advantage achieved in carieslike inhibition in this study over the previous research is that the low power irradiation of the He-Ne laser.

By using high power lasers there is high risk of accident irradiation to the adjacent hard and soft tissues, in addition to the risks on the operators and dental staff. Beside that, high power laser requires heavier and more expensive systems. These systems require more spaces, more skills and more safety precaution. He-Ne laser system is smaller in size and could be handled easily. Accident exposure to the surrounding tissues is not important because of low absorption of that tissues to 632.8 nm wavelength.

Methylene blue plays a major role in this study. He-Ne laser wavelength (632.8 nm) lies within the absorption peaks of methylene blue. That may explain the significant difference between the carieslike inhibition of group I (with methylene blue) and group II (without methylene blue).

Thus according to present study, the role of the dye in laser carieslike lesion inhibition is important in the

localization of its effect on the irradiated area.

Conclusions

According to this study, successful carieslike lesion inhibition could be achieved to 29% extent, by using low power dye assisted He-Ne laser irradiation.

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Tab (1): Statistical data with ANOVA test

Source of variation	SS	df	MS	F	P-value
Between groups	186394.4	2	93197.2	2324.764	P<0.0001
Within groups	1082.4	27	40.08889		
Total	187476.8	29			

Tab (2): Sample groups and the related caries inhibition percentages.

Group	Lesion Depth mean ± SD (µm)	Caries Inhibition (%)
Group I	410.4±6.9	29
Group II	574±6.1	1.2
Control	581±6.1	0