Root Caries Prevention Potential of Chopped CO_2 Laser: an In Vitro Study

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Abstract

The objective of this study aimed to assess the caries-preventive potential of various chopped CO_2 laser parameters, and to explore the effect of the laser energy density on the caries inhibition activity.

Roots of extracted human premolar teeth were irradiated with three various energy densities (25.47, 50.93, and 101.86) J/cm^2, by changing the number of pulses, the pulse duration, and the spot diameter. The CO_2 laser system emitted laser with 10.6μm in wavelength. All roots were subjected to carieslike lesion formation by 3.5 pH lactic acid for 21 days. The roots after that were sectioned into ground cross sections and the lesion depths were measured under a polarizing microscope.

Chopped CO_2 laser preventive treatments inhibited carieslike lesion progression up to 36%. This effect was improved with decreased total energy density within the limits of the examined laser parameters.

Keywords: Root, Caries, Chopped, CO_2, Laser

Introduction

Most of epidemiological studies have demonstrated the increasing prevalence of root surface caries in the adult and elderly population.[1-3]

The onset of root surface caries parallels the loss of gingival attachment due to periodontal disease and exposure of the root surface to the oral environment. The highly caries susceptible cemental surface may rapidly develop root surface caries.

Primary prevention of root surface caries involves maintenance of the gingival attachment and avoidance of gingival recession by effective plaque control.[2] However once the root surface has become exposed; preventive measures need to be instituted to avoid caries initiation. Both systemic and topical fluoride agents have been shown to provide significant protection against root caries.[4-6]Laser technology may also provide a certain degree of resistance against root surface caries.[6-11]

In recent years, the effects and interactions of lasers with dental hard tissues have been studied.[12-15]The overall objective of these studies was to determine optimal laser use parameters for clinical caries prevention. These parameters should decrease the tooth surface's susceptibility to caries without jeopardizing the pulp vitality.

The aim of this study is to evaluate the chopped CO_2 laser inhibition of the root artificial carieslike lesion within various parameters, and to explore the effect of the energy density, the No of pulses and the pulse duration of this laser on the caries inhibition activity in order to determine the optimal chopped

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CO_2 laser parameters used for this purpose.

Materials and methods

A total of twenty-four extracted sound newly erupted human premolar teeth (extracted for orthodontic purpose) were selected for this in vitro study. The collected teeth were placed in deionized distilled water and stored in the refrigerator to avoid dehydration. Following prophylaxis with fluoride - free pumice (Alfred Becht Germany), these teeth were examined under a reflected light microscope (Baush & Lomp) at a magnification of 30X to ensure that they were defect-and caries free. The surface of each root was covered with acid-resistant varnish (QD England) leaving two circular windows of approximately (4-6) mm in diameter on the proximal surfaces of the middle third of the roots.

These teeth were separated in to 3 groups of (Group I, II, and III). Each group was subdivided into 3 subgroups 3(A-C) according to which laser parameters were applied, in addition to one group served as a control. The samples were irradiated using chopped CO_2 laser (BLITZ 50 SV, asa medical laser, Vicenza, Italy) with 10.6μm wavelength at (25.47, 50.93, and 101.86) J/cm^2 energy densities. The energy density in group I was changed by changing the number of the pulses (2,4 and 8 pulses). In groups II and III the energy densities were changed as a function of pulse duration (0.002, 0.004 and 0.008 in seconds) and spot diameter (4, 2.83 and 2 mm) respectively. Tree teeth were excluded from CO_2 irradiation to use them as a control group (Table 1).

Carieslike lesion were created on all roots by immersing them in 3.5 pH lactic acid solution (Fluka A Switzerland) and incubated for 21 days at 37ºC (Memmert incubator Germany). After the period of incubation the samples were embedded in clear acrylic cubes. Cross sections were prepared at the center of the irradiated areas and microscopic slides were prepared from them. Microscopic 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. The percents of caries inhibition were estimated using the formula:

$$\frac{\text{(lesion depth of experimental samples- lesion depth of control samples)*100\%}}{\text{lesion depth of experimental samples}}$$

Results

Table (2) gives the variation in mean lesion depths and caries inhibition percentage by various chopped CO_2 laser parameters.

One way analysis of variance showed that there was significant effects between the irradiated and control groups as illustrated in table (3).In general, all of laser-treated subgroups have much or less decrease in lesion depths compared with the control group. The maximum caries inhibition percent (36%) was corresponding to subgroup A3. Subgroups C1, C2 and C3 represented minimum caries inhibition percentages (14%).

Fig 1 represents he behavior of the caries inhibition percentage as a function of the CO_2 energy density for groups I, II, and III. It shows that there is an inverse relationship between them. The lesser the energy density (25.47 J/cm^2) -regardless the way we reduced it with- produces the higher caries inhibition percentage (31%, 21% and36% respectively).

Discussion

Although the effects of laser irradiation on dental caries were explored some 30 year ago, [16-18] the risk of thermal damage to the adjacent supporting hard and soft tissue and the pulp was such that much of the research was abandoned. However with improved laser technology, a number of different type of laser with varying tissue penetration and energy (flounce) levels have been developed.[19] Currently, it is possible to collimate the beam to a specific diameter, focus the beam to a certain depth and control the energy (flounce) emitted from the laser and absorbed by the tissue.[19] This has allowed the clinician to optimize the laser effect on hard or soft tissue while minimizing the transmission of thermal energy to adjacent tissue. At the present time, a number of laser which emit different wavelengths (Nd:YAG 1.06 µm; CO_2 10.6 µm; Argon 488 nm and 514 nm) and varied energy levels have been adapted for use in dentistry.[19] With these advances in laser technology, there has been a renewed interest in laser irradiation and caries prevention.

The inhibition of in vitro carieslike lesion progression achieved by laser treatment alone in this study represents one of the most promising findings ever reported in the literature for laser treatment. A single exposure to chapped CO_2 laser irradiation of sound root resulted in signified reductions in lesion depth up to 36% inhibition percentage.

The enhanced caries resistance of root surface following laser irradiation may be due to many factors [20-22]: -

1- Alteration in the root surface composition.
2- Increased affinity of lased root surface for fluoride, phosphate and calcium ion uptake.
3- Creation of microsieve network within the tooth structure.
4- Surface melting and recrystallization.
5- Decreased root surface permeability.
6- Bactericidal effect and elimination of the dental plaque.
7- Formation of calcium fluoride surface deposits in the presence of exogenous fluoride

The exact mechanism of caries resistance with laser irradiation seems to be due a combination of some or all of previously listed factors at the same time, according to the depths and temperatures of the root surface layers.

Although the artificial caries system used in this study creates lesions in root surface that are identical histologically to root surface caries formation in vivo, one must consider that this system subjects the root surface to a continuous aggressive, cariogenic challenge without periods of remineralization. In contrast caries formation in vivo is characterized by periods of demineralization interspersed with periods of remineralization with oral fluids. Despite the continuous cariogenic challenge, the lased root surface demonstrated a remarkable resistance to lesion initiation.

It is important to know that the all sets of laser parameters used in this study produce temperature increment less than 5°C at the pulp side [23]. The pulp vitality is not affected [24]. Cooling the surface of the tooth in vitro with water decreased the pulpal temperature change [25]. The assumption is that in vivo, the temperature change would be lower than in vitro because of the effects of the saliva and the blood flow.

Conclusions

From this in vitro study one can concluded that:-

1- Short exposure time of chopped CO_2 laser results in a significant

inhibition of the root artificial carieslike lesion.

2-The inhibitory effect inversely related to the total energy density of the laser beam.

3-The optimal chopped CO_2 laser parameter used for caries inhibition purpose is achieved with approximately 25.47 J/cm^2 energy density.

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Tab (1): Sample groups and the related chopped CO_2 laser parameters.

Group	Parameter	
Group I	No. of Pulses	Total Energy Density (J/cm^2)
A1	2	25.47
B1	4	50.93
C1	8	101.86
Group II	Pulse Duration (s)	Total Energy Density (J/cm^2)
A2	0.002	25.47
B2	0.004	50.93
C2	0.008	101.86
Group III	Spot Diameter (mm)	Total Energy Density (J/cm^2)
A3	4	25.47
B3	2.83	50.93
C3	2	101.86

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

Group		Lesion Depth mean (μm)	Caries Inhibition (%)
Group I	A1	400	31
	B1	441.67	26
	C1	500	14
Group II	A2	458.33	21
	B2	433.33	26
	C2	500	14
Group III	A3	375	36
	B3	475	19
	C3	500	14
Control		583.33	0

Tab (3): Statistical data with ANOVA test

Source of variation	SS	df	MS	F	P-value
Between groups	33095.2381	6	5515.873	3.082723	P<0.05
Within groups	25050	14	1789.286		
Total	58145.2381	20			

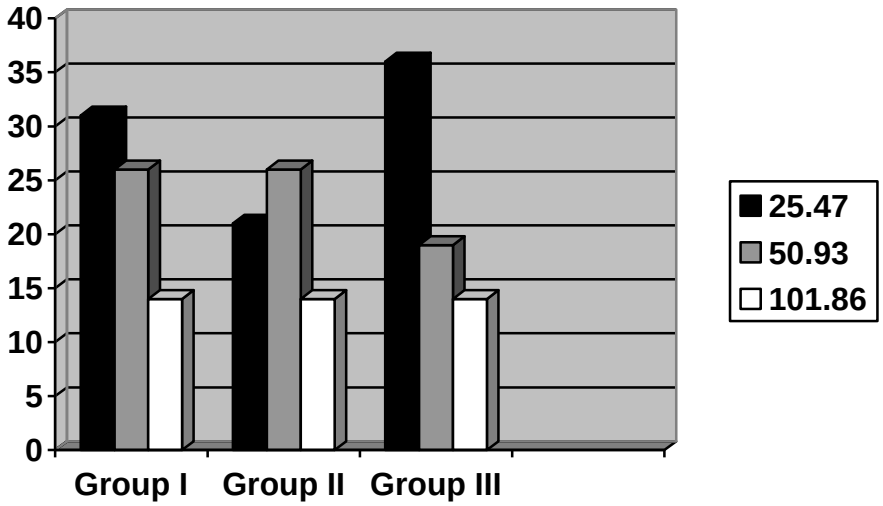

Fig (1): The relation between the energy densities and the caries inhibition percentages in groups I, II and III.