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Effects of Irradiation of Continuous Wave Carbon Dioxide Laser on Caries Resistance of Deciduous Teeth

Muthenna Sh. Rajab BDS, MSc. [(1)]
Shatha A. Salih BDS, MSc. [(2)]
Abdul Rahman M. Saleh BDS, MSc. [(3)]

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Abstract

The objective of this study aimed to assess the caries-preventive potential of various CW CO_2 laser parameters, and to explore the effect of the laser power density on the caries inhibition activity.Extracted human deciduous molars were irradiated with three various power densities, by changing the output power, the exposure time, and the spot diameter. The CO_2 laser system emitted laser with 10.6µm in wavelength. All teeth were subjected to carieslike lesion formation by 3.5 pH lactic acid for 21 days. The teeth after that were sectioned into ground cross sections and the lesion depths were measured under a polarizing microscope.CW CO2 laser preventive treatments inhibited carieslike lesion progression up to 82%. This effect was improved with increasing power density within the limits of the examined laser parameters.

Introduction

Despite the substantial decline in the prevalence of dental caries, it continues to be a major dental disease of human beings, young and old [(1)]. Dental caries is the most prevalent chronic disease of childhood in communities[(2,3)] . Caries in children at the age 0-5 years, called early childhood caries, has been reported as endemic health problem worldwide [(4)]. It is five times more prevalent than asthma [(5)]. Although caries affects both deciduous and permanent dentitions, it progresses more rapidly in deciduous enamel than permanent enamel[(1)]. The enamel of deciduous teeth is only half as thick of permanent teeth[(6)]. Moreover, it has a lower mineral content and higher organic content,[(7)] rendering it more susceptible to carious lesions than the enamel of permanent teeth [(8)]. The first application of laser technology to dentistry was for the removal of caries infected material and preparation of cavities [(9)] . However, ever since reports of laser application on improvement of dental surface were emerged, much attention has been focused on the laser's potential to enhance enamel's hardness and resistance to acid [(10)]. Irradiation of dental hard tissues with a laser beam results in the formation of more stable and acid resistant compounds, with possible creation of re-mineralization micro-spaces that entrap free ions and reduce acid attack susceptibility [(11)]. Carbon dioxide laser irradiation has been shown to be highly effective in inhibiting caries progression in enamel, [(12, 13)]the observed caries inhibition found to be up to 81% [(14-16)].This effect may be due to the higher absorption of CO_2 laser wavelength (10.6 µm) in phosphate radicals of the hydroxyapatite crystals [(17)]. However these studies were carried out on permanent teeth. As high percentage of demineralization inhibition

(1)Ass. Professor, Department of Conservative Dentistry, College of Dentistry, University of Tikrit.
(2)Lecturer, Department of Conservative Dentistry, College of Dentistry, Hawler Medical University.
(3)Ass. Professor, Department of Conservative Dentistry, College of Dentistry, Ajman University of Science & Technology.

have been observed for CO_2 laser-irradiated permanent enamel, it seems reasonable to speculate that such effect may also be achieved using laser irradiation on deciduous enamel. This study aimed to evaluate the ability of continuous wave carbon dioxide (CW CO_2) laser in inhibiting the enamel carieslike lesion on deciduous teeth, and to explore the effect of various laser parameters (power density, exposure time and spot diameter) on the caries inhibition in order to determine the optimal CW CO_2 laser parameters used for this purpose.

Materials and Methods

A total of twenty four extracted sound deciduous molars were used for this study. All soft tissues were removed and the teeth were subjected to super-fine fluoride-free pumice polishing. Reflected light microscope was used to examine the teeth and to detect any surface abnormality (to be discarded). The teeth were then immersed in distilled water and stored in the refrigerator at 4ºC to avoid teeth dehydration. Before laser irradiation, the teeth were painted with acid resistant varnish leaving two windows buccally and lingual with 4-6mm in diameter. According to the selected laser parameters, the teeth were randomly divided into four groups :A, B, C and group to serve as a control. In group A the spot diameter was the variable. In group B. the variable was the exposure time. The output power was the variable in group C. The samples were irradiated using CW CO_2 laser (BLITZ 50 SV, as a medical laser Vicenza, Italy) with 10.6 µm wavelength (table 1).After laser irradiation, the samples were immersed in lactic acid solution (pH 3.5) at 37ºC and incubated for 21 days to produce carieslike lesion. Following that period, cross sections were prepared through the centers of the buccal and lingual windows. Lesion depths were measured using a graticule supplied with the polarizing microscope (Zeiss Germany).Single factor ANOVA statistical analysis was applied to the result. (Table 2).The caries inhibition percentages of the experimental samples were estimated using the formula:

Caries inhibition percentage = (mean lesion depth of control sample – mean lesion depth of experimental samples * 100%)/ mean lesion depth of control sample

Results

Table 2 shows mean, standard deviation and the significance of the irradiated samples from A1 to C3. All irradiation parameters resulted in significant reduction in lesion depth compared with the control group. In table 3 the caries inhibition percentages were derived from the lesion depths of each subgroup. Group A showed that there is increase in caries inhibition percentage by reduction of the spot diameter of the laser beam. Caries inhibition percentage in group B showed direct relationship with the exposure time to the laser. Finally, the output power of the laser in group C showed direct relationship to the caries inhibition percentage.

Discussion

Although the effects of continuous wave carbon dioxide laser irradiation on dental caries were explored some 30 years ago,[9-14] it seems that this effect on deciduous teeth did not take sufficient researches. Most of researches in this field focused on the laser caries inhibition of permanent enamel [9-14] . However, some researchers conducted their experiment on bovine teeth [15]. According to current study, continuous wave carbon dioxide laser irradiation significantly affects the caries inhibition of deciduous enamel. This effect may reach to 82% caries reduction in mean lesion depth in group A1 (fig 1)when compared with mean lesion depth of control samples (fig 2).Generally, this finding are in good agreement with those reported for caries inhibition created with CO2 laser on permanent teeth[12-16]. But in relation to details, there are several differences corresponding to which laser parameters used. In group A there is increase in caries inhibition with the increase of the power density achieved by reduction of the laser spot diameter. This may be due to the condensation effect of laser beam on the

irradiated spot. By manipulation of the laser output power in group C, there is similar effect observed in group A (increase of the caries inhibition by increasing the power density achieved by increasing the output power).In group B, the increase of the exposure time with fixed power density did not produce significant effect. This may concluded that the power density of the CW CO_2 laser plays the major role in caries resistance of deciduous enamel. Comparable findings with similar parameters of CW CO_2 laser were performed on permanent enamel, showed that there is a direct relationship between the power density and the caries inhibition percent just like this study, but there is inverse relationship between the exposure time and the caries inhibition in permanent enamel. The later effect did not found on deciduous enamel in this study. This may be related to the differences between deciduous and permanent enamel. The deciduous enamel is more porous, less mineralized, has more carbon dioxide and carbonate and less phosphorous and calcium phosphate in its composition[18-23].

deciduous enamel has less organized microcrystals[21]and a greater diffusion
The outline and arrangement of enamel rods are similar in deciduous and permanent teeth[24] but coefficient[20]. Furthermore, deciduous teeth presents with an aprismatic enamel layer on the surface[25]. The artificial caries in this study is more aggressive compared to in vivo caries which is characterized by period of demineralization interspersed with period of remineralization with oral fluids. Despite of continuous cariogenic challenge, irradiated enamel demonstrated remarkable resistance to lesion formation. The selected laser parameters in this study do not produce promenant increase in temperature at pulp side with the consideration of cooling system supplied with in vivo laser application.

Conclusion

Continuous wave carbon dioxide laser irradiation results in a significant increase in caries resistance of deciduous enamel. This enhancement of deciduous enamel reaches as high as 82%.

Fig. (1):- Lesion depth in A1 sample.

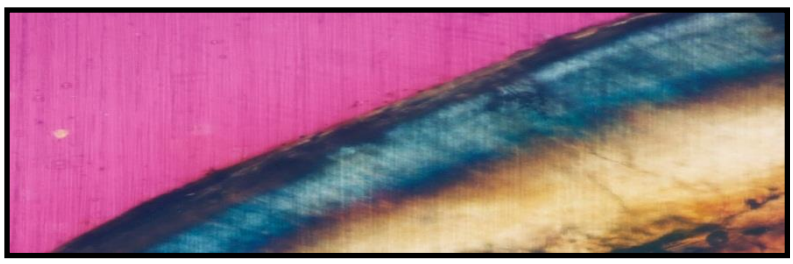

Fig. (2):- Lesion depth in control sample.

Table (1):- Experimental groups and related CW CO_2 laser parameters.

Group	Power (W)	Exposure time (s)	Spot diameter (mm)	Power density (W/cm^2)
A1	4	0.8	2	127.32
A2	4	0.8	2.83	63.59
A3	4	0.8	4	31.83
B1	4	0.8	2	127.32
B2	4	0.4	2	127.32
B3	4	0.2	2	127.32
C1	4	0.8	2	127.32
C2	2	0.8	2	63.59
C3	1	0.8	2	31.83

Table (2):- Lesion depths of experimental groups in relation to control group.

experimental lesion depth			control lesion depth		*P-value*	*Significance (P<0.05)*
group	mean	SD	mean	SD		
A1	116.64	4.8	648	22.9	5.56E-06	s
A2	174.96	10.6			1.195E-05	s
A3	434.16	19.7			0.0005587	s
B1	116.64	4.8			5.56E-06	s
B2	136.08	5.7			6.671E-06	s
B3	187.92	13.0			1.584E-05	s
C1	116.64	4.8			5.56E-06	s
C2	265.68	12.8			3.258E-05	s
C3	498.96	23.6			0.0030462	s

Table (3):- Experimental groups and related caries inhibition percentages.

Group	Caries inhibition (%)
A1	82
A2	73
A3	33
B1	82
B2	79
B3	71
C1	82
C2	59
C3	23
Control	0

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