



The Effect of Laser Irradiation on the Thickness of the Caries Surface Zone

Dr. Muthenna Sh. Rajab.*

Dr. Hikmet A. Sh. Al-Gharrawi.*

Abstract

The objective of this study aimed to assess the relation between various CW CO₂ laser parameters and the thickness of the surface zone in the created carieslike lesion.

A total of twenty four extracted human premolar teeth were irradiated with three various power densities (63.66, 31.83, and 15.9) W/cm². The CO₂ laser system emitted laser with 10.6μm in wavelength. All samples were subjected to 3.5 pH lactic acid for 21 days to form carieslike lesion. The crowns after that were sectioned into ground cross sections and the surface zone thicknesses were measured under a polarizing microscope.

Continuous wave (CW) CO₂ laser had a noticeable effect on the prominence of the surface zone. The mean of the surface zone thicknesses found to be directly related to the power density of CW CO₂ laser.

Keywords: Surface, Zone, Caries, CW, CO₂, Laser

Introduction

During lesion formation, four distinct zones of enamel caries may be observed. Two zones the translucent zone and the body of the lesion represent area of demineralization; while the dark zone and the surface zone represent areas of remineralization with in the lesion of enamel⁽¹⁻²⁾. This study concerns only the surface zone, the most superficial zone of enamel caries.

The appearance of a surface zone as being one of the zones of caries, and not just the resistant sound enamel surface, was first described by Silverstone⁽³⁾. This relatively unaffected surface zone is usually about 30 μm in depth and has a pore

volume of approximately 1 per cent. If the lesion progresses, this surface layer is eventually destroyed and a cavity forms.

When the surface zone is thick enough, it is considered to be characteristic of an "arrested" lesion, since the lower permeability may protect the underlying lesion from further progression and cavitation⁽⁴⁾.

The relation between the laser parameters and the caries inhibition activity of the lasers were studied previously. The aim of this study is to assess the relationship between the CO₂ laser parameters and the presence of the surface zone in the carieslike lesion in vitro.

Materials and Methods

A total of twenty four newly erupted human premolar teeth extracted for orthodontic purposes were selected for this in vitro study. Following a fluoride -free prophylaxis, these teeth were examined under a light microscope at a magnification of 30X to ensure that they were defect- and caries free. The surface of each crown was covered with acid-resistant varnish leaving two circular windows buccally and lingually of approximately (4-6) mm in diameter.

These teeth were divided in to 3 experimental groups according to which laser parameters were applied, in addition to one group served as a control. Each group consisted of six samples. The windows on buccal and lingual surfaces of the experimental groups' samples were irradiated using CW CO₂ laser (BLITZ 50 SV, asa medical laser, Vicenza, Italy) with 10.6 μm wavelength and 10 Hz repetition rate. The power densities applied to group I, II and III were (63.66, 31.83 and 15.9) W/cm² respectively.

Carieslike lesions were created on buccal and lingual windows of the crowns of the experimental and control groups by immersing them in lactic acid solution (pH 3.5) at 37°C. Following a period of 21 days of incubation, the crowns were cross-sectioned at the center of carieslike lesions to prepare microscopical slides. These slides were examined under polarizing microscope (Zeiss Germany). The surface zone thicknesses of the carieslike lesion were measured using a graticule supplied with the polarizing microscope. The percents of increase in the surface zone thickness were estimated using the formula:

$$\frac{(\text{surface zone thickness of experimental samples} - \text{surface zone thickness of control samples}) * 100\%}{\text{surface zone thickness of control samples}}$$

surface zone thickness of control samples

Finally, photomicrographs were taken to the samples.

Results

Table (1) gives the variation in mean surface zone thicknesses by various CW CO₂ laser parameters.

One way analysis of variance showed that there were significant deference between the irradiated and control groups as illustrated in table (2) The surface zones appeared up to 80% thicker in the laser treated samples fig (1) and (2).

There is a direct relationship between the power density of the CW CO₂ laser and the thickness of the surface zone. The higher the power density (63.66W/cm²) produces the thicker surface zone (80%) fig (2).

Discussion

Several models have been proposed to explain the relative protection against further dissolution of the outer 10-30 microns of enamel. A protective role of salivary praline-rich proteins and other salivary inhibitors, such as statherin, has also been emphasized ⁽⁵⁾. These inhibit demineralization and prevent crystal growth. They are macromolecules and cannot penetrate the deeper parts of the enamel; thus, their stabilizing role is limited to the surface enamel, but this is unlikely to play a significant role in caries lesion inhibition in this in vitro study.

The outer enamel is special in terms of its ultra structure and chemical composition ⁽⁶⁾. However, artificial carieslike lesions with subsurface demineralization can be formed in teeth from which the surface

of the enamel has been removed, and also in compacted blocks of essentially fluoride free synthetic hydroxyapatite.

A physicochemical explanation seems important. Some physicochemical system seems to exist at the tooth surface which helps to preserve it, almost as if the surface loses ions to the outside but regains them from the deeper enamel ⁽⁷⁾. Dissolution is caused by an under saturation with respect to enamel apatite and a formation of fluorapatite in the enamel surface caused by a super saturation with respect to fluorapatite ⁽⁸⁾.

Fluoride in solution has been demonstrated to influence formation and thickness of the surface zone covering a carious enamel lesion ^(9, 10).

In this study, the enamel surface irradiation with CO₂ laser lead to thicker and more prominent surface zone without fluoride application. This may be due to the effects produced by the CO₂ laser irradiation on the outer layers of the enamel. The enamel surface shows alteration in its chemical composition after laser irradiation ⁽¹¹⁾.

With laser irradiation, the composition of enamel may be altered with reduction in organic, carbonate, and water content ⁽¹²⁾. The removal of the water molecules and the organic materials by the laser thermal effect leads to formation of microspaces ⁽¹³⁾. During demineralization of subsurface enamel structure, the microspaces created by laser irradiation may trap the released ions and act as sites for mineral reprecipitation. This deposition of released mineral phases may be further enhanced by the fact that lased enamel has an increased affinity for fluoride, phosphate and calcium ions ^(14, 15). The higher power density of CW CO₂ laser leads to more penetration of its effect within the enamel surface. This may explain the direct relationship between the power

density and the thickness of the surface zone.

Conclusions

From this in vitro study one can concluded that CW CO₂ laser had a noticeable effect on the thickness of the surface zone. The mean of the surface zone thicknesses found to be directly related to the power density of CW CO₂ laser.

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Tab (1): Sample groups and the related CW CO₂ laser parameters.

	Power density (W/cm ²)	Increase in surface zone (%)
Group I	63.66	80
Group II	31.83	75
Group III	15.9	67
Control	0	0

Tab (2): Statistical data with ANOVA test

Source of variation	SS	df	MS	F	P-value
Between groups	1963.3333	3	654.4444	175.2976	1.5852E-14 P<0.0001
Within groups	74.6667	20	3.7333		
Total	2038	23			



Fig (1) Cross section of carieslike lesion on enamel surface of control group in polarizing microscope.



Fig (2) Cross section of carieslike lesion on enamel surface of group of 63.66 W/cm^2 power density in polarizing microscope.