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The effect of the CO_2 laser on the enamel cracks

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Abstract

The objective of this study aimed to assess the effeats of the CO_2 laser on the enamel cracks. The labial cracks of thirty extracted central incisors were irradiated with 4 Watts power and (0.4, 0.2 and 0.1) pulse durations. The laser used was CO_2 laser with 10.6 µm in wavelength. The irradiated samples were sectioned into ground cross sections and examined under polarizing microscope. Enamel cracks can not be welded completely using CO_2 laser irradiation. Although the formation of superficial glaze layer, there was a tendency to increase in the separation of the crack sides as the pulse duration of the laser increased

Keywords: Enamel, Crack, CO_2, Laser

Introduction

Human teeth are subjected to many changes in temperature each day and each time the temperature changes the teeth undergo thermal stress. The magnitude of the stress is proportional to the temperature change in the tooth.

A tooth is a composite structure of complex geometry, constructed from materials the properties of which differ from one component to another and are anisotropic (direction sensitive) and non homogeneous (position sensitive)[(1)].

Careful examination of in vivo teeth with an intense light source often reveals cracks in the enamel. These cracks have generally been attributed to the mastication process, accidents, abnormalities in the maturation process, or to thermal stresses resulting from the ingestion of hot or cold food and drink[(2)].

Enamel is a highly mineralized tissue with the crystallites arranged in a preferred orientation along the c axis of the prismatic unit [(3)]. The resulting anisotropy means that there is a plane of cleavage approximately at right angles to the surface plane of enamel, parallel to the so-called c axis [(4,5)]. Thus, while enamel demonstrates the biological advantages of hardness and wear resistance in the occlusal plane, it shows brittle fracture in planes approximately at right angles to the occlusal, incisal, and labial planes of the teeth. The fracture plane in enamel requires the separation of crystals which lie side by side and is energetically favored[(6,7)]. Due to its brittleness, enamel requires the presence of underlying dentin to transmit and dissipate the occlusal force [(4,8)].

Dentinoenamel junction zone may play a significant role in resisting the enamel crack. This reflects the fact, that in the intact tooth, the multiple full

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thickness cracks commonly found in enamel do not typically cause total failure of the tooth by crack extension into the dentin[9].

Natural enamel fracture could be due to high loads (static or impact) leading to catastrophic failure, or could be due to fatigue growth of a crack followed by failure under a low load. Fatigue failure might be due to repeated loading from chewing, thermal cycling from hot and cold foods, or combinations of both [10].

In previous studies, several types of lasers have been studied with regarded to altering hard-tissue permeability [11-17], glazing the dentin surface [18-20] and endodontically sealing the apical foramen [21,22].

In root cracks, fracture line in dentin could be covered with the glaze layer resulting from CO_2 laser irradiation at the proper exposure parameters, then the leakage through the fracture interface could be substantially reduced [23].

The purpose current study is to evaluate the effect of CO_2 laser on the sealing and glazing of the enamel cracks.

Materials and Methods

A total of 30 upper central incisors were selected from the extracted teeth. The selection based upon the presence of enamel cracks on the labial surface of the teeth crowns. During collection, the samples were immersed in top water and stored in the refrigerator within 4°C. The control group consisted of 6 teeth. The other 24 teeth were used as experimental groups. The roots of these samples were mounted in plaster bases. The experimental samples were irradiated with 4 Watts of CO_2 laser (BLITZ 50 SV, asa medical laser, Vicenza, Italy). The experimental samples were divided into three groups according to pulse duration were applied. In group I the pulse duration was 0.4 sec, while in group II and III, the pulse durations were 0.2 and 0.1 sec respectively. The irradiated areas were photographed with camera (Sony cybershot DSC F828 Japan). Cross sections were prepared to the experimental and control samples to make microscopical slides. These slides were examined under the polarizing microscope (Zeiss Germany). Photomicrographs were taken by camera fixed with the polarizing microscope

Results

The irradiated surface of enamel crack showed white spots which represent the irradiated areas. These white spots had glaze surface with raised periphery and shallow depth in the center (Fig 1، 2 and 3).

The diameters of these spots seemed to be directly related to the laser pulse duration. In group I the spots were larger in size and more distinguished than group II and III as shown in fig 1، 2 and 3 respectively.

The separation between the crack sides were more in group I where we used higher pulse duration (Fig-1) while in group III there was less separation (Fig-3).

In polarizing microscope the enamel showed separation in facture line from the surface to the dimtinoenamel junction in group 1 (Fig- 4).

However the outer surface of the enamel was covered by a thin layer this layer was similar to the inorganic substance of enamel in birefringence.

These findings appeared also in group II where the pulse duration is less (Fig-5). But the separation of the enamel crack was less than the group I.

In group III (fig-6) there was no separation in the crack line and the surface layer was less pronounced than groups I and II.

Fig 7 represents the control group. The crack line showed no separation and lack of surface layer.

Discussion

In this experiment, tooth crack were treated with CO_2 laser beam in an attempt to melt the enamel.

Most of the treated specimens exhibited the same or slightly more crack separation than did the untreated control specimens. However, there did seem to be a tendency for increased separation as energy densities increased.

Thermally induced changes observed in this study included dehydration of the tissue and expansion of the fracture line. As laser energy is absorbed by the tissue, water temperature rises, and this ultimately results in conversion to steam at temperatures above 100ºC, causing desiccation or dehydration of the tissues. The resultant steam also has the ability to cause tissue vaporization and sterilization of the site.

The results of the present study suggest that fusion would not occur under such conditions caused by tissue dehydration and subsequent increased separation of the line of fracture.

The lack of fusion in the present study may be due to the phase transformation of the tissues that could not be controlled. When the target tissue is exposed to the laser, melting and vaporization occur after the transformation of the solid to a liquid and subsequently the liquid to a gaseous state. However, the melted state could not be sustained long enough to achieve a fluid that would bridge the fracture and then resolidify.

Scanning electron microscopic (SEM) observation of carbon dioxide (CO_2) laser effects on dental enamel has revealed evidence of melting and crystal fusion [24-25].

The central melt region although rough, was covered by a thin, smooth, fused, glaze-like surface layer. Cross sections of these zones revealed that the effect of the laser extended approximately 5 µm below the enamel surface [26].

The glaze layer produced on the enamel surface does not have available effect on the crack sealing. As the glaze layer is brittle, it cannot be relied on for strength, and a non stabilized fracture conceivably could fracture the glaze layer during movement and negate any sealing effect.

However some studies indicate that enamel crack may become sealed or filled by a soft organic substance in vivo, but they apparently are never structurally repaired [27].

Another more recent study finds amorphous mineral deposits inside enamel cracks. These deposits composed of hydroxyapatite and whitelockite and had the ability to occlude enamel cracks naturally [28].

Short exposure time of chopped CO_2 laser results in a significant inhibition of the enamel artificial carieslike lesion [29]. This may be useful in the enamel crack to increase the caries resistance of this critical region.

Conclusions

Enamel cracks can not be welded completely using CO_2 laser irradiation. Although the formation of superficial glaze layer, there was a tendency to increase in the separation of the crack sides as the pulse duration of the laser increased.

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Fig (1): Labial crack after irradiated with 0.4 sec pulse duration of CO_2 laser (group I).

Fig (2): Labial crack after irradiated with 0.2 sec pulse duration of CO_2 laser (group II).

Fig (1): Labial crack after irradiated with 0.1 sec pulse duration of CO_2 laser (group III).

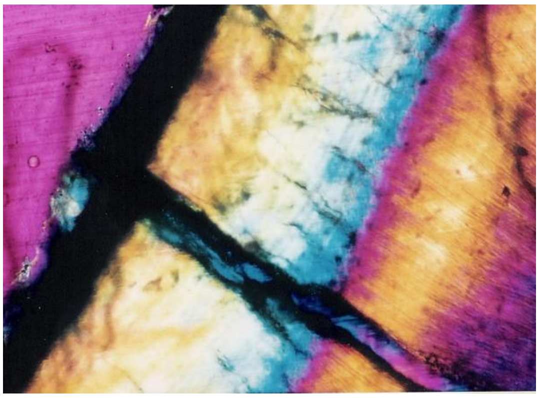

Fig (4): Cross section of labial crack after irradiated with 0.4 sec pulse duration of CO_2 laser (group I) examined under polarizing microscope.

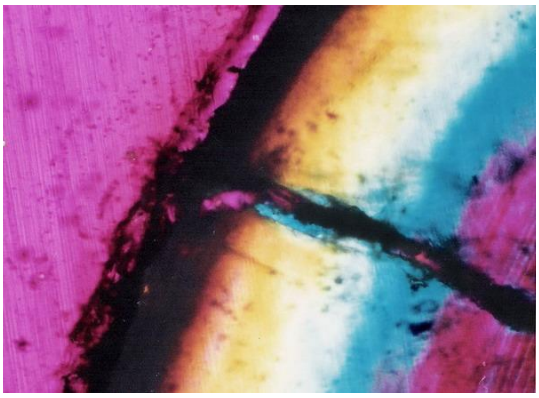

Fig (5): Cross section of labial crack after irradiated with 0.2 sec pulse duration of CO_2 laser (group II) examined under polarizing microscope.

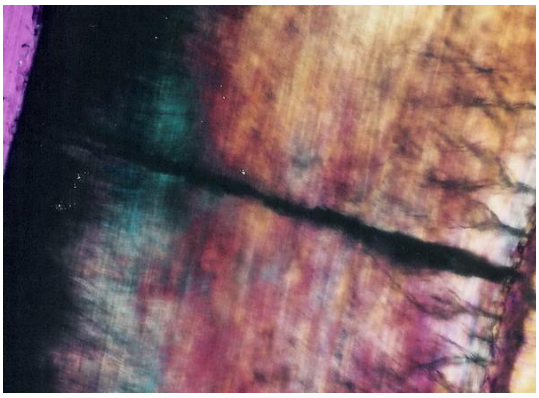

Fig (6): Cross section of labial crack after irradiated with 0.1 sec pulse duration of CO_2 laser (group III) examined under polarizing microscope.

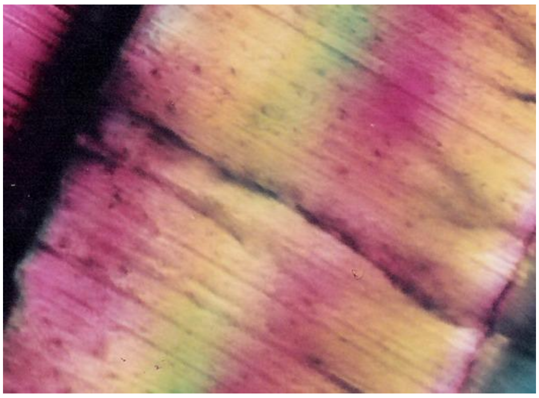

Fig (7): Cross section of labial crack on the control group examined under polarizing microscope.