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Developing Consistency in Enamel Etching by CO_2 Laser

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ABSTRACT

It has been reported that CO_2 laser energy can be utilized to etch enamel. However, consistency of etching has been a significant problem. This research was designed to ascertain which exposure parameters result in consistent etching of enamel. Fourteen non-carious teeth were selected and a 2x4 gridwork was cut into the buccal surfaces creating eight discrete windows for laser exposures. Four teeth served for the initial pilot project. Two windows were lased at each combination of exposure parameters. Laser exposures were at .01, .02, .05, or .10 sec. at 2, 5, 10, or 15 Watts (W) with a model 20C Pfizer CO_2 laser. A 1.0mm focal spot was used throughout. Following SEM examinations, it became clear that etching occurred only at .05 and .10 sec. at 10 and 15W. Ten teeth were used for the main project at .05 and .10 sec. exposures at 10 and 15W. Ten windows were lased for each combination of exposure parameters. SEM analysis was accomplished at 100X and 1,200X. 10/10 laser exposures at .05 sec./15W, .10 sec./10W and .10 sec./15W resulted in etched enamel. Statistical analysis showed a significant difference in etching between the .05 sec.10W group and the higher exposure parameters ($p = .003$). The results indicate that CO_2 laser energy can consistently etch enamel at .10 sec. at 10 or 15W and at .05 sec. at 15W with a 1.0mm focal spot.

1. INTRODUCTION

Etching of enamel and dentin for resin bonding procedures has been explored as another clinical application of laser energy in dentistry. This technique could provide the clinician with a faster procedure as well as eliminate the potential for contamination during the rinsing-air-drying sequence. An increased body of research has been conducted in this area during the last decade using different types of lasers, which include the carbon dioxide (CO_2)[1-5], argon-ion[6], Nd-YAG[7-10], and excimer[11].

Scanning electron microscopy (SEM) has shown that CO_2 laser energy has the potential to produce a rougher enamel surface than standard acid etching[12]. This phyisical modification may increase bond strength through micro-mechanical retention. However, exposure parameters necessary for consistency of etching have not been delineated. This research project was designed to ascertain which combination of exposure parameters will result in consistent etching of enamel with CO_2 laser energy.

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2. MATERIALS AND METHODS

Tooth Preparation

A total of fourteen sound human extracted third molars, collected from an oral surgeon, were used in this study. They were stored in deionized water with thymol for periods of up to 2 months. Molars were debrided of all soft tissue, and cleansed ultrasonically in deionized distilled water for 5 minutes. The roots of each tooth were cut off half the distance from the apex to the cementum enamel junction with a carbide disc to facilitate mounting for SEM examination. A 2x4 gridwork was cut into the buccal surfaces with a tapered diamond bur (high speed handpiece) creating eight discrete windows for laser exposure per tooth.

Laser Treatment

Four teeth were selected for the initial pilot project (Figure 1). Two windows were lased at each combination of exposure parameters. Laser exposures were at .01, .02, .05, and .10 sec. at 2, 5, 10, and 15 watts (W) respectively with a model 20C Pfizer CO_2 laser. A 1.0 mm focal spot was used throughout. Each tooth was coated with 60% Au + 40% Pd alloy for SEM examination.

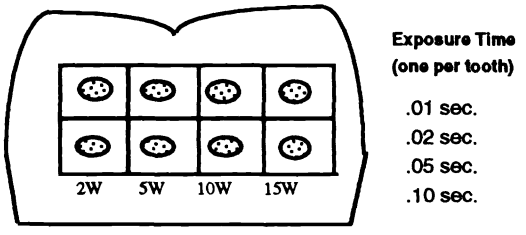

Figure 1: Combination of exposure parameters (exposure time and wattage) used in the pilot study (4 teeth).

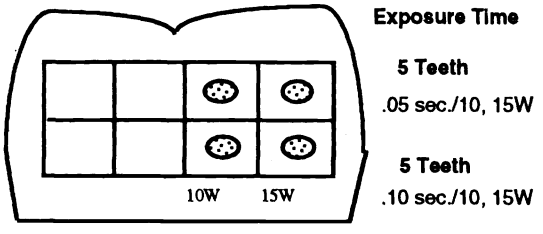

Figure 2: Combination of exposure parameters (exposure time and wattage) used in the main study (10 teeth).

Scanning electron microscopic analysis at 100X and 1,200X revealed that etching occurred only at .05 and .10 sec. at 10 and 15 W respectively. Ten teeth were then divided in two groups for the main project. Group #1 (.05 sec. / 10 and 15 W) and group #2 (.10 sec. / 10 and 15W). Only four windows per tooth were lased at this stage (Figure 2). Ten windows were lased for each combination of exposure parameters. These teeth were also coated with 60% Au + 40% Pd alloy and mounted for SEM examination.

3. RESULTS

Scanning electron microscopy analysis revealed that 10/10 laser exposures at .05 sec./15W, .10 sec./10W and .10 sec./15W resulted in etched enamel. At .05 sec./10W, 6/10 exposure sites showed etching. Non-parametric statistical analysis (p= .003) showed a significant difference in etching between the .05 sec./10W group and the higher exposure parameters. However, some fused enamel areas were observed within the etched zones.

4. DISCUSSION

Under the conditions of this study, it appears that CO_2 laser energy can consistently etch enamel. These results are encouraging. The power density across the beam was found to be non-uniform ("hot spots" were observed), which could account for the fused enamel areas found within the etched zones. Further research with a more uniform power density CO_2 laser is underway in an attempt to eliminate the fused areas, and to ascertain the effects of overlapping laser exposures.

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