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Marginal Leakage in Class V Cavities Pretreated with Different Laser Energy Densities

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ABSTRACT

The purpose of the present study was to evaluate *in vitro* the degree of marginal leakage in Class V cavities involving the cementoenamel junction. Cavities were 4 mm wide and 2 mm deep. The specimens received dentin pretreatment (37% phosphoric acid) followed by the Single Bond (3M) adhesive system application. The 40 specimens were then divided into four groups: Group 1 (control); Group 2 (Nd:YAG laser at 120 mJ/pulse, frequency of 10 Hz, power of 1.2 W); Group 3 (Nd:YAG laser at 140 mJ/pulse, frequency of 10 Hz, power of 1.4 W); Group 4 (Nd:YAG laser at 160 mJ/pulse, frequency of 10 Hz, power of 1.6 W). The cavities were restored with Z100 composite resin (3M) and light cured at 300–600 mW/cm^2 light intensity. Specimens were thermocycled to 500 cycles from 2–50°C. After that, they were dried and sealed with nail varnish, respecting 1 mm around the restorations, and immersed in 0.5% methylene blue solution for 4 h. After this period, the teeth were rinsed, dried, sectioned, and analyzed in a stereoscopic loupe. The highest leakage scores were considered for each specimen. The results were statistically analyzed by the analysis of variance (ANOVA) – Kruskal-Wallis test to the 5% level. For both the enamel and cementum, there was a decrease in marginal leakage with the application of laser energy; no significant differences were observed for Groups 2, 3, and 4. The results also showed a smaller tendency to marginal leakage on the cementum than on the enamel.

INTRODUCTION

THE USE OF LASERS IN RESTORATIVE DENTISTRY has been extensively studied as a substitute for burs during cavity preparation, as treatment for dentin hypersensitivity, and as dentin pretreatment before the application of adhesive systems. Investigation of laser application continues because of its capacity to seal the dentin tubules and form tags, which could assist in mechanical adhesion, removal of the smear layer, and opening of the dentin tubules, or even in dentin melt, depending on the energy level used.

The Nd:YAG laser was first used as a treatment for the hard tissues of teeth when its pulp effects were proven to be much less aggressive than the effects of the ruby laser. This premise was corroborated by the studies of Adrian and Washington[1] in 1977. In a similar study by Dostálová et al.,[7] to determine the power of enamel and dentin ablation with the Er:YAG, it was verified that this laser is safe and noninvasive.

In a more recent study, Gonçalves et al.,[9] analyzed the action of the Nd:YAG laser as pretreatment for normal and mineralized bovine dentin on the shear bond strength test of the Scotchbond Multi-Purpose Plus adhesive system. The study evaluated the effects of acid etching, laser irradiation/adhesive system, and adhesive system/laser irradiation. The author suggested that irradiation of dentin previously treated with the adhesive system still in the presence of adhesive monomers could result in more stable bonding and in a lower degree of marginal leakage, extending the life expectancy of the restoration.

However, within the literature there is still substantial controversy over energy characteristics and the type of laser used for each type of tissue (enamel, dentin, and cementum). Therefore, this study contributes to the literature aimed at standardizing laser parameters for adhesive purposes in dentin. The intention of our research was to evaluate the influence of dentin pretreatment with adhesive, combined or not with Nd:YAG laser of varying energy densities, as mentioned by Gonçalves et al.[9] The

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latter obtained excellent results in shear bond strength by combining adhesive with laser.

MATERIALS AND METHOD

The materials used in this study—compositions, batch numbers, and respective manufacturers—are listed in Table 1.

Preparation of the specimens

Forty bovine incisors were mounted, by the roots with their long axes perpendicular to the worktable. Standardized Class V preparations (4-mm diameter and 2 mm depth) were performed with diamond burs #3053 (KG Sorensen) in the mid cervical-vestibular region of the teeth, including the cementoenamel junction, using a microscope adapted for this purpose. The surfaces were then cleaned with detergent solution (Tergensol, INODON, Brazil) to remove oily residue from the micromotor. Next, the teeth were rinsed with water for 10 s and dried with filter paper to dehydrate the exposed dentin.

Dentin pretreatment

The teeth were divided into four groups, with 10 specimens in each, according to the procedure used for the pretreatment. Therefore, the following distribution of subgroups was obtained:

Group 1—37% phosphoric acid, adhesive system SB (3M), and light curing for 20 s
Group 2—37% phosphoric acid, adhesive system SB (3M), light curing for 20 s, and Nd:YAG laser (10 Hz, 1.2 W, 120 mJ/pulse)
Group 3—37% phosphoric acid, adhesive system SB (3M), light curing for 20 s, and Nd:YAG laser (10 Hz, 1.4 W, 140 mJ/pulse)
Group 4—37% phosphoric acid, adhesive system SB (3M), light curing for 20 s, and Nd:YAG laser (10 Hz, 1.6 W, 160 mJ/pulse)

After pretreatment, specimens received composite resin restoration and light curing and were stored in distilled water for 24 h at 37°C. Finishing and polishing followed.

All of the restorations were made using Z100 composite resin by the incremental technique in two portions, bling each portion was light cured for 40 s. The same light-curing unit was used for each step and the light intensity was 450 mW/cm^2.

Analysis of marginal leakage

Specimens were thermocycled in alternate baths from 2–50°C (± 2°C) for 500 cycles (Ética Thermocycling Machine). Then specimens were dried, received three layers of red nail varnish, without covering the restorations, and immersed in 0.5% Methylene Blue solution for 4 h. After this period, the specimens were rinsed in tap water and sectioned sagittally with 1-mm cuts with a low-speed diamond saw (Labcut 1010 – Extec) and evaluated for marginal leakage.

The degree of marginal leakage on the interface tooth/restoration was evaluated with a stereoscopic loupe (Tecnival, Carl Zeiss). The criteria for leakage analysis was:

0 degree—no leakage
Degree 1—up to 1/3 of the gingival and/or incisal wall
Degree 2—up to 2/3 of the gingival and/or incisal wall
Degree 3—all gingival and/or incisal wall
Degree 4—all gingival and/or incisal wall and axial wall
Degree 5—all gingival and/or incisal wall, axial wall, and into the pulp chamber

Two calibrated examiners, in a blinded study, performed the analysis. The greatest leakage scores for each specimen, for both gingival margin in cementum and incisal margin in cementum, were considered.

Statistical analysis

The results observed were recorded and submitted to the analysis of variance (ANOVA) – Kruskal-Wallis test at the 0.05 significance level.

RESULTS

The primary purpose of this study was to evaluate the influence of the combination of adhesive and different laser energy intensities on the marginal leakage of Class V preparations.

The statistical model ANOVA—Kruskal Wallis test at the 0.05 significance level presented $p = 0.002$ for the enamel and $p < 0.001$ for the cementum (Figs. 1 and 2).

TABLE 1. MATERIALS USED IN THE STUDY: CHARACTERISTICS AND MANUFACTURER

Materials	*Composition/characteristics*	*Manufacturer*
Adhesive—single bond	Acid + primer/adhesive	3M Brazil
Laser Nd:YAG	Noncontact; Energy—120, 140, and 160 mJ/p; frequency——10 Hz; power—1.2, 1.4, and 1.6 W; spot-size—2 mm	Pulse Master 600 IQ American Dental Technologies, Inc.
Composite resin Z100	Hybrid	3M

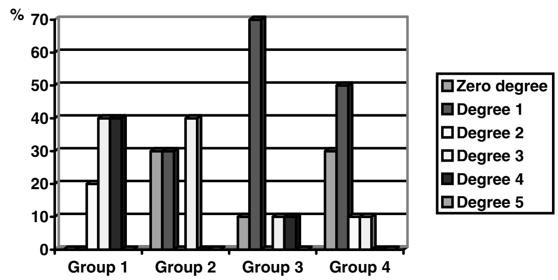

FIG. 1. Percentage of microleakage for enamel by groups.

DISCUSSION

Since the introduction of the acid-etching technique by Buonocore[4] in 1955, researchers in dentistry have been developing materials and techniques that can provide adhesive restorations free of marginal leakage. The purpose of this study was to increase the knowledge base of laser energy usage and to evaluate the influence of the combination of adhesive and laser in decreasing marginal leakage.

The use of laser after the application of an adhesive system seemed viable because of the results obtained by Gonçalves et al.,[9] who suggested the technique, and Eduardo et al.,[8] who corroborated their studies. Our results compared the efficiency of these methods, with the best results found in the groups treated with laser.

According to Figures 1 and 2, less marginal leakage was observed in the laser groups, in both the enamel and cementum, compared with the control group. Superior results were observed for Groups 3 and 4 (140 and 160 mJ, respectively) in relation to Groups 1 and 2 (control and 120 mJ, respectively). Therefore, our results agree with the trend suggested by Gonçalves et al. in their studies:[9] the formation of a substrate constituted of melted hydroxyapatite when laser was used after the application of the adhesive system increases the shear bond strength and consequently reduces marginal leakage. Cooper et al.[6] also showed favorable results with the use of laser in their work, obtaining an increase of about 300% in the shear bond strength. However, they used CO_2 laser prior to the application of an adhesive system of the second generation. Therefore, we can suggest that the combination of adhesive and laser is promising for the marginal sealing of adhesive restorations.

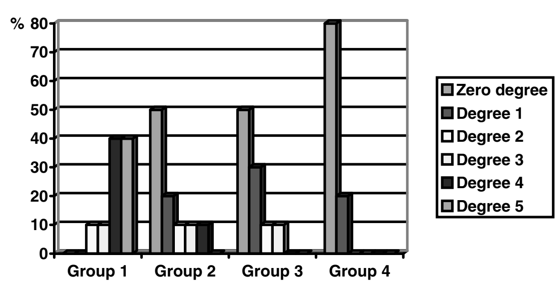

FIG. 2. Percentage of leakage scores for cementum by groups.

Researchers such as Kinney et al.[10] believe that the creation of a layer of recrystallization of the apatite can be induced by different types of laser, wavelength, pulse, and densities; this phenomenon was also observed in our study, in which the intensities of laser energy used in Groups 3 and 4 (140 and 160 mJ, respectively) promoted more efficient marginal sealing. However, despite not showing a significant statistical difference, Group 4 presented a tendency for better results.

Moreover, significant statistical differences were observed in the groups that were exposed to laser (Groups 2, 3, and 4), when the marginal leakage in the enamel and cementum were compared, the best results being obtained for the cementum. It is possible that the laser potency used was insufficient for the desired action on the enamel, which is a tissue containing more mineral content and may demand higher energy intensity for the fusion of the enamel to the adhesive.[9] Thus, the time of Nd:YAG laser application on the enamel, dentin, and cementum should be further analyzed in order to promote its use in dentistry.

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