Shear Bond Strength to Primary Enamel: Influence of Er:YAG Laser Irradiation Distance

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ABSTRACT

Purpose: The purpose of this study was to evaluate in vitro the influence of Er:YAG laser irradiation distance on the shear bond strength of an adhesive restorative system to primary enamel. **Methods:** Fifty buccal surfaces of extracted human canines were ground and divided into 5 groups (N=10). The control group was etched with 35% phosphoric acid (CA). In the lased groups, the enamel surface treatment was performed with the Er:YAG laser (80mJ/2Hz) by varying the irradiation distance (12, 14, 16, and 17 mm), followed by acid etching. An adhesive agent (Single Bond) was applied on the bonding sites, and resinous cylinders (Filtek Z250) were prepared. Shear bond strength tests were performed in a universal testing machine (0.5 mm/minute). Failure mode was assessed using a X40 magnification stereomicroscope. Data were submitted to statistical analysis by analysis of variance. **Results:** The means in MPa were: (1) CA=18.76 (±6.68); (2) 12 mm=12.73 (±5.46); (3) 14 mm=15.9 (±6.81); (4) 16 mm=20.1 (±6.94); and (5) 17 mm=15.15 (±6.81). There was no statistically significant difference (*P*<.05) among the tested groups. **Conclusion:** The different Er:YAG laser distance irradiations did not influence the adhesive resistance of the resinous system to enamel, even when compared with the control group (acid etching solely). (J Dent Child 2007;74:26-9)

KEYWORDS: ER:YAG LASER, PRIMARY TEETH, ENAMEL, SHEAR BOND STRENGTH

Since the introduction of the acid etching of enamel by Buonocore[1] in 1955, adhesive procedures in dentistry have been refined, mainly in the 2 last decades. The mechanism of adhesion of the restorative systems to enamel by means of acid etching is widely accepted and has effectiveness that is supported by numerous studies.[2-4]

Recently, new methods have been introduced to improve adhesion and reduce microleakage in the enamel/sealant interface, such as Er:YAG laser treatment, which has been applied alone or followed by phosphoric acid etching.[5-7]

When applied on a hard tooth structure, the Er:YAG laser promotes tissue removal by a thermomechanical interaction, producing microexplosions and vaporization, depending on the energy employed during irradiation. Thus, Er:YAG laser irradiation could create a more suitable surface for adhesion, generating a microretentive pattern by creating rugosities on the enamel surface.[8] The effect of the Er:YAG laser on target tissues, however, relies on various parameters, including the:

1. irradiation distance (the distance between the beam output and the substrate);
2. laser beam focus (focused or defocused laser beam irradiation mode);
3. irradiation length;
4. energy and pulse repetition rate (frequency);
5. tissue water content; and
6. air/water spray cooling.[7,9-13]

Although some research[14-17] has proved the effectiveness

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Table 1. Means Values (MPa) of Shear Bond Strength and Standard Deviations (SD) of the Experimental Groups

Group	Surface treatment	Mean±(SD)*
1	35% phosphoric acid	18.76±6.68a
2	Er:YAG laser (12 mm)+35% phosphoric acid	12.73±5.46a
3	Er:YAG laser (14 mm)+35% phosphoric acid	15.90±6.81a
4	Er:YAG laser (16 mm)+35% phosphoric acid	20.10±6.94a
5	Er:YAG laser (17 mm)+35% phosphoric acid	15.15±6.81a

**Groups with the same superscript letter are statistically similar (P>.05).*

of Er:YAG laser irradiation on the surface treatment of dental enamel, as compared to the traditional acid conditioning, variable results have been shown.[7,18,19] Described irradiation distances ranged from contact mode to 17 mm working distance, on focused and/or defocused modes. No reported studies compare different irradiation distances, however, with respect to their effect on the adhesion of resin systems to primary enamel surface.

This study's aim was to investigate the influence of the Er:YAG laser, applied at different irradiation distances, on shear bond strength of an esthetic restorative system to primary enamel. The null hypothesis tested was that:

1. There is no difference in the bonding to nonlased and lased primary enamel.
2. The working distance does not influence the adhesion to this substrate.

METHODS

Fifty sound primary canines exfoliated or extracted within a 6-month period and stored in 0.4% sodium azide solution at 4°C were selected and carefully cleaned with water/pumice slurry using dental prophylaxis cups. When necessary, roots were sectioned 2 mm below the cementoenamel junction and crowns were embedded in polyester resin using P5C (polyvinyl chloride) rings (2.1 cm diameter and 3 cm height) in such a way that buccal surfaces were exposed.

After resin polymerization, the rings were discarded and the buccal surfaces of teeth were ground in a polishing machine (Politriz, Struers A/S, Copenhagen, DK-2610, Denmark) using water-cooled no. 320- to no. 600-grit silicon carbide paper to expose a flat enamel surface. To delimit the enamel bonding site, a piece of insulating tape with a 2-mm-diameter central hole, made by means of a modified Ainsworth rubber-dam punch, was attached to the specimen surface. The limitation of the bonding site had a double aim, to:

1. define a fixed test surface, in such way that the shear bond strengths recorded would be related solely to the evaluated area; and
2. warrant that the truncated resin composite cylinder would be further adhered precisely to the treated enamel surface, thus avoiding accidental adhesion to the surrounding untreated enamel).

The specimens were rinsed and stored in distilled water at 37ºC for 24 hours. The 50 specimens were randomly assigned to 5 groups of equal size (N=10), according to the surface treatment.

The experimental groups are detailed in Table 1. Since it has been demonstrated[19] that application of the laser only (ie, without further acid etching) yielded markedly low bond strength to enamel, a group irradiated with the Er:YAG laser alone was not included in this study.

The Er:YAG laser device used was the Kavo Key Laser 2 model (Kavo Dental GmbH & Co.KG, Biberach, Germany), emitting a 2.94-µm wavelength. The parameters used were: (1) 80 mJ energy; (2) 2 Hz pulse repetition rate; and (3) 28.30 J/cm^2 energy density. The laser beam was delivered on noncontact mode under a fine water mist of 5 mL/minute. A 2051 handpiece, attached to the flexible fiber delivery system, was used. The irradiation distance was standardized using a custom designed apparatus that positioned the handpiece in such a way that the laser beam was delivered perpendicular to the specimen surface at a constant working distance from the target site. Irradiation time was 20 seconds.

Phosphoric acid was applied for 30 seconds, followed by rinsing and removing excess water with absorbing paper. For the tested adhesive system, the bonding protocol was followed according to the manufacturer's instructions:

1. Two consecutive coats of Single Bond (3M ESPE)—an ethanol-and-water-based, total-etch single-bottle bonding agent—were applied with disposable tips (Microbrush Corporation, Orlando, Fla).
2. The remaining solvent was evaporated with a brief, mild air-blast.
3. The adhesive was light cured with a visible light-curing unit (XL 3000, 3M ESPE), with a light output not less than 450 mW/cm,2 for 10 seconds.

After the bonding protocol was completed, specimens were individually fixed in a metallic clamping device (developed at the Houston Biomaterials Research Center and manufactured at the Precision Workshop at the Ribeirão Preto School of Dentistry, University of São Paulo, São Paulo, Brazil), keeping the enamel surface parallel to a flat base. A split-bisected polytetrafluoroethylene jig was positioned on the tooth/resin block surface, thus providing a cylindrical cavity coincident with the demarcated 2-mm-diameter bonding site.

A hybrid composite resin (Z250, 3M ESPE) was inserted into the jig in increments, each polymerized for 40 seconds. As the matrix cavity was filled, the specimen was removed from the clamping device and the matrix was opened, leaving a resin composite cylinder with a 3-mm diameter and 4-mm height adhered to the demarcated enamel surface.

After 24-hour storage in distilled water at 37ºC, each cylinder-shaped composite/acrylic resin block was loaded in tension, using a universal testing machine (model no. MEM 2000, EMIC Ltda, São José dos Pinhais, PR, Brazil), at a crosshead speed of 0.5 mm/min and a 50 kgf load cell until fracture. Shear bond strengths values were recorded in kgf and converted into MPa. Means and standard deviations were calculated, and data were analyzed by analysis of variance (ANOVA).

Fractured specimens were observed with a X40 stereomicroscope (Nikon Inc, Instrument Group, Melville, NY) to assess the failure modes, which were classified as: (1) adhesive; (2) cohesive; or (3) mixed. Failure was considered:

1. adhesive if it occurred at the specimen/adhesive interface;
2. cohesive if it occurred in the material or the substrate, with no damage to the interface; and
3. mixed if it involved the interface and the material or substrate concurrently.

RESULTS

Shear bond strength means and standard deviations for each experimental group are shown in Table 1. ANOVA showed no statistical difference (P>.05) among the means of shear bond strength obtained for the distinct experimental groups.

The analysis of the failure modes demonstrated that adhesive failures were prevailing for groups 2 (70%), 4 (50%), and 5 (60%). In groups 1 and 3, however, an alteration in the failure mode occurred, with a superiority of mixed failures of 70% and 60%, respectively. Cohesive failures were scarcely observed in any group: (1) group 1=10%; (2) group 2=0%; (3) group 3=10%; (4) group 4=10%; and (5) group 5=10%.

DISCUSSION

Since the work by Buonocore[1] about acid etching of enamel, researchers have sought a better adhesive agent for enamel and dentin. With the advent of new technologies, such as the Er:YAG laser, studies were conducted observing the influence of this device on dental tissues, mainly for preparation and surface treatment of enamel and dentin.[7,20-24] Tanji et al[24] found that the Er:YAG laser presented good interaction with dental hard tissue and promoted increased shear bond strength in comparison with acid etching. Moreover, the Er:YAG laser can efficiently ablate enamel and dentin.[25,26]

The effectiveness of the Er:YAG laser for surface enamel treatment was considered by some authors[5,12,27] as similar to the conventional acid etching, verifying the formation of irregularities on the laser-irradiated enamel and promoting higher bond strength values. A later study[28] of adhesive resistance observed changes in the micromorphological aspect of Er:YAG-lased enamel, but these alterations were not sufficient for improving resin adhesion to enamel when compared to acid etching alone. This result has been supported by several authors,[7,22,23] who suggested the association of laser and acid to achieve higher adhesion when the Er:YAG laser treatment was followed by phosphoric acid etching.

The interactions of the laser with the biological tissues depend on the characteristics of the target tissue itself and the laser device, such as the: (1) wavelength; (2) optical properties of the tissue; (3) emission mode (pulsed or nonpulsed); (4) delivery system (contact or noncontact); (5) irradiation time[29]; (6) water cooling[30]; (7) irradiation distance[10,13]; (8) pulse energy; and (9) pulse repetition rate.[11,12,25,30,31]

There is concern about the Er:YAG laser irradiation distance and resultant heat on dental hard tissues and the compromising of adhesion.[32] A previous study[13] evaluated the influence of Er:YAG laser distance variation on the adhesive resistance of the dentin/resin interface of permanent teeth. This previous study indicated that the distance of 17 mm followed by phosphoric acid etching was similar to control group (only acid), and the other distances (11, 12, 14, and 16 mm)—also followed by phosphoric acid etching—presented lower results. In the present study that evaluates the shear bond strength to primary enamel, the different irradiation distances followed by acid application were similar to acid etching alone. Notwithstanding, it is difficult to compare the results of this work due to the lack of studies in the literature establishing definite parameters for Er:YAG laser irradiation in primary teeth.

Although the Er:YAG laser has been noted as a promising technology in dentistry, there is still much to be investigated on the: effect on primary tooth structure; adhesive interface micromorphology; and alterations in substrate compounds. Further in vitro and in vivo research on the action of acid etching in lased surfaces are mandatory to justify the use of such protocols in clinical practice and to assess the longevity of restorations under realistic oral conditions.

CONCLUSION

Based on the results of the present in vitro study and the methodology employed, different Er:YAG laser irradiation distances did not influence the shear bond strength of a restorative system to primary enamel.

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