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Effect of erosive challenge and Nd:YAG laser irradiation on bond strength of adhesive systems to dentin

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A B S T R A C T

Purpose: To evaluate the effect of Nd:YAG laser irradiation and erosive challenge on bond strength of two adhesive systems to dentin.
Methods: Twenty bovine incisors were cut and grounded to obtain eighty slabs of flat dentin. Specimens were allocated into eight groups, based on: adhesive system—a two-step etch-and-rinse and a two-step self-etch; laser irradiation—Nd:YAG (1 W/10 Hz) or control (no laser irradiation); and erosive challenge after restorative procedure—presence or absence of erosive challenge. Nd:YAG laser groups were submitted to laser irradiation before the restorative procedure. Blocks of composite resin were built up on the bonded surfaces with a Southern Dental Industries device to perform shear bond strength (SBS) test. After, each specimen of erosive challenge, groups were subjected to immersion in Sprite Zero® (20 ml/2 h/24 °C/under agitation). The SBS test (0.5 mm/min) was performed after 24 h of water storage at 37 °C. Failure mode was evaluated with a stereomicroscope (X400). Data were analyzed with three-way ANOVA and Tukey's *post hoc* tests ($\alpha = 0.05$).
Results: The etch-and-rinse adhesive system presented higher bond strength values than self-etch adhesive. Laser irradiation increased the bond strengths values when erosive challenge was present. The predominant failure mode observed was adhesive.
Conclusions: The irradiation of Nd:YAG laser positively influences the bond strength values when erosive challenges are present. Moreover, the etch-and-rinse adhesive system is a better option to be used in dentin in this clinical condition.

1. Introduction

Changes in eating habits have been reported as one of the main reasons for the prevalence of health problems in a large part of the population [1,2]. Nowadays, the increasing ingestion of citric fruits, soft drinks, juices and yogurt has been claimed as the main causing factor of erosion lesions in permanent and primary teeth [3–6]. Dental erosion is the result of surface dissolution of the mineralized dental tissues caused by acids without any microbiological involvement [7]. This phenomenon can be responsible for morphological changes in the dentinal tissue, such as an increase in the number of widened dentinal tubules [8,9]. Therefore, these alterations in the dentin tissue will facilitate the fluid displacement and will ultimately stimulate the pulp mechanic-receptors, leading to acute and localized pain [10].

Dental erosion has been associated with the prevalence of dentin hypersensitivity [11,12]. The effective treatment of dental erosion should decrease teeth sensibility and prevent the formation of new lesions by means of the elimination of predisposing factors, like harmful eating habits or gastroesophageal reflux. Changing the patients eating habits is not an easy task. Some desensitizing agents have been recommended in an attempt to reduce tooth sensitivity; however, their effectiveness is transitory as they act only as pain relievers [13].

The lack of an effective treatment to dental erosion has encouraged the development of new approaches to control dentin hypersensitivity. Application of Nd:YAG laser to the exposed dentin surface showed satisfactory results in clinical trials, with

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reductions of 88% in the sensibility rate [14–16]. These results were further confirmed in a recent systematic review [17]. This type of laser treatment occludes the dentinal tubules by dentinal fusion and subsequent tissue solidification [18], reducing the demineralization process and progression of the lesion [19,20].

One important aspect of laser treated erosion lesions is that they usually need to be restored with resin composites in order to reconstruct the correct dental anatomy, improving esthetics and function of the affected teeth [21]. To the authors' knowledge, there is no study in the literature that investigated the influence of Nd:YAG laser on the bond strength of adhesive systems to dentin when the erosive challenge is maintained after the restorative treatment. This last feature is particularly important because it is has been shown that the erosion challenge usually persists after the restorative procedure and little information is available on the effect of such challenge on the longevity of bonded restorations.

Thus, the purpose of this study was to evaluate the effect of Nd:YAG laser irradiation and erosive challenge on the bond strength of two adhesive systems to dentin. The hypothesis tested is that there is no influence of both Nd:YAG laser irradiation and erosive challenge on the bond strength to dentin.

2. Materials and methods

Twenty freshly extracted bovine incisors were selected and stored in 0.01% (w/v) thymol solution at 4 °C for 1 month until the beginning of the study. The root portion of each teeth was removed in the transversal plane, and the coronal portion was sectioned in the mesiodistal and cervico-occlusal direction using a cutting machine with low speed water-cooled diamond saw (Isomet 1000, Buhler, Lake Bluff, IL, USA) to obtain eighty dentin slabs with dimensions of 4.5×4.5 mm^2. Specimens were then embedded in self-curing acrylic resin (JET Clássico®, São Paulo, SP, BR) and the surfaces were ground with 180, 400 and 600-grit SiC paper for 30 s under running water to ensure a flat dentin and uniform smear layer.

2.1. Experimental groups

Specimens were randomly assigned into eight experimental groups, based on: adhesive system (one two-step etch-and-rinse, Adper Single Bond 2; 3M ESPE, St. Paul, MN, USA, and one two-step self-etch, Adper SE Plus; 3M ESPE, St. Paul, MN, USA); laser irradiation (Nd:YAG laser or control—no laser irradiation); erosive challenge after restorative procedure (presence or absence of erosive challenge) (Fig. 1). The absence of erosive challenge was simulated in distilled water. These groups resulted in a $2 \times 2 \times 2$ factorial experimental design with 10 specimens in each subgroup. Compositions and manufacturer's instructions of the adhesive systems are summarized in Table 1.

2.2. Laser irradiation

Specimens from laser irradiation groups (G2, G4, G6, G8) were irradiated with a Nd:YAG laser (Power Laser™ ST6, Lares Research®, Chicago, CA, USA) with a quartz fiber of 300 μm and wavelength of 1064 nm. The irradiation protocol used was: power of 1 W, repetition rate of 10 Hz, 100 mJ of energy and ~80 J/cm^2 of energy density, in contact mode [15,22], with scanning movements, two times for 10 s each (one in horizontal and the other in vertical direction), with an interval of 20 s between them to allow thermal relaxation of the tissue, without air cooling, in VLP mode (very long pulse). The quartz fiber was always cleaved after 5 irradiated specimens.

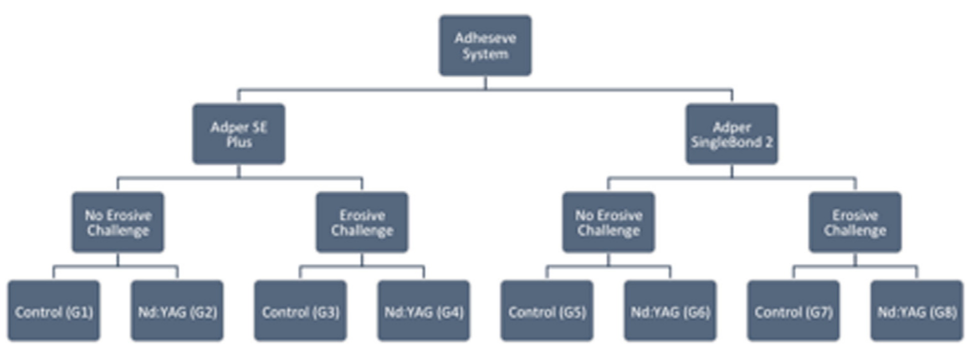

Fig. 1. Experimental groups description.

Table 1
Adhesive systems; characteristics, general composition, manufacturers and manufacturers' instructions.

	Adper Single Bond 2	Adper SE Plus
Characteristics	Two-step etch-and-rinse adhesive system	Two-step self-etch adhesive system
Composition	Etchant: 35% phosphoric acid Adhesive system: HEMA, ethanol, water, Bis-GMA, dimethacrylate, amines, methacrylic copolymer of polyacrylic and polyitaconic acids, and photo initiator.	Primer: water, HEMA, surfactant, pink colorant Adhesive: UDMA, TEGDMA, TMPTMA, HEMA, methacrylated phosphates, bonded zirconia nanofiller, initiator system based on camphorquinone
Manufacturer	3M ESPE St. Paul, MN, USA	3M ESPE St. Paul, MN, USA
Manufacturers' instruction	Etch tooth surface with acid etchant for 15 s then rinse for 10 s; blot excess water with cotton pellet; apply 2 coats of bond with rubbing motion for 15 s; air-thin for 5 s; and light-curing for 10 s.	Apply primer; apply adhesive with a brush and rubbing motion for 20 s; apply other coat of adhesive and air-thin for 10 s; and light-curing for 10 s.

Abreviations: Bis-GMA: bis-phenol A diglycidylmethacrylate; HEMA: 2-hydroxyethyl methacrylate; UDMA: urethane dimethacrylate; TEGDMA: Triethylene glycol dimethacrylate; TMPTMA: hydrophobic trimethacrylate.