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ORIGINAL ARTICLE
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Can Nd: YAG laser irradiated on dentin with non-polymerized adhesives influence the durability of bond strength and micromorfology of hybrid layer?

Pode o laser Nd:YAG irradiado sobre a dentina impregnada com adesivos não polimerizados influenciar na durabilidade da resistência de união e micromorfologia da camada híbrida?

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ABSTRACT

Objective: This study evaluated the durability of bond strength to dentin using total-etch (Single Bond /SB) and self-etch (Clearfil SE Bond/CSEB) adhesives associated with Nd:YAG laser irradiation through the unpolymerized adhesives. Also, this study evaluated micromorfological chances in hybrid layer after 12 months water storage. **Material and Methods:** Bovine incisors were worn to expose a dentin area and were divided into 4 groups (n = 15): Group 1 (Control) – SB + photopolymerization; Group 2 (Control) – CSEB + photopolymerization; Group 3 (experimental/ laser) - SB + Nd:YAG laser (149.28 J/cm^2) + photopolymerization; Group 4 (experimental/ laser) – CSEB + Nd:YAG (149.28 J/cm^2) + photopolymerization. Composite blocks were fabricated; intact teeth were stored for 24 h or 12 months (12 m), sectioned into beams and submitted to microtensile bond strength tests. Two teeth from each group (n = 2) were prepared for SEM analysis. **Results:** For interaction Adhesive X Technique X Storage time the mean values (MPa) were: SB/Control/24h = 34.05(± 6.14)a; CSEB/ Control/24h = 32.12(± 5.26)a; SB/laser/24h = 30.54(±5.94)a; CSEB/laser/24 h = 29.45(±5.11) a; SB/Control/12 m = 29.36(± 5.57)a; CSEB/ Control/12 m = 29.09(± 8.84)a; SB/laser/12m = 22.06(±3.77)b; CSEB/laser/12 m = 13.35(± 3.35)c. Conclusions: SEM showed evident areas of

RESUMO

Objetivo: Este estudo avaliou a durabilidade da resistência de união à dentina utilizando adesivo convencional (Single Bond/SB) e autocondicionante (Clearfil SE Bond/CSEB) associados a irradiação do Nd: YAG laser sobre os adesivos não-polimerizados. Esse estudo também avaliou mudanças micromorfológicas da camada híbrida após armazenagem por 12 meses em água. **Material e Métodos:** incisivos bovinos foram desgastados para expor uma área de dentina e foram divididos em 4 grupos (n = 15): Grupo 1 (controle) - SB + fotopolimerização; Grupo 2 (Controle) - CSEB + fotopolimerização; Grupo 3 (experimental/laser) - SB + laser Nd:YAG (149,28 J/ cm2) + fotopolimerização; Grupo 4 (experimental/ laser) - CSEB + laser Nd:YAG (149,28 J/cm2) + fotopolimerização. Os dentes foram restaurados com resina composta e armazenados por 24 h ou 12 meses (12 m), seccionados em palitos e submetidos a testes de resistência de união à microtração. Dois dentes de cada grupo (n = 2) foram preparados para análise em MEV. Os resultados foram analisados por ANOVA três-fatores (Adesivo, Técnica e Armazenamento) e teste de Tukey (0,05). **Resultados:** Resultados para interação Adesivo X Técnica X Armazenamento (valores médios MPa): SB/Controle/24 h = 34,05 (± 6,14) a; CSEB/Controle/24 h = 32,12 (± 5,26) a; SB/laser/24 h = 30,54 (± 5,94) a; CSEB/laser/24 h = 29,45 (± 5,11) a; SB/Controle/12 m = 29,36 (± 5,57) a; CSEB/Controle/12 m = 29,09 (±

micromorphological alterations on lased samples after 12 months water storage with accelerated degradation of the hybrid layer. Bond strength decreased when dentin irradiated with the Nd:YAG laser through unpolymerized adhesives was stored in water for 12 months. Laser irradiation of dentin through unpolymerized self-etch adhesive significantly reduced bond strength when compare with total-etch adhesive after 12 months water storage. **Clinical Implication:** Nd:YAG laser irradiation, performed on dentin surface with non-polymerized adhesives, can influence negatively the durability of bond strength and, consequently, the durability of resin composite restorations.

KEYWORDS

Dental cements; Dentin; Laser, solid-state; Tensile strength.

8,84) a; SB/laser/12 m = 22,06 (± 3,77) b; CSEB/laser/12 m = 13,35 (± 3,35) c. **Conclusão**: Análise de MEV mostrou áreas evidentes de alterações micromorfológicas em amostras irradiadas após 12 meses de armazenamento de água com a degradação acelerada da camada híbrida. A resistência de união diminuiu quando a dentina foi irradiada com o laser Nd: YAG através de adesivos não-polimerizados, e seguida de armazenagem em água por 12 meses. Irradiação do laser Nd:YAG sobre a dentina impregnada com adesivo autocondicionante não polimerizado reduziu a resistência de união em comparação com adesivo convencional após 12 meses de armazenamento de água.

PALAVRAS-CHAVE

Cimentos dentários; Dentina; Laser, estado sólido; Resistência à tração.

INTRODUCTION

After nearly 4 decades of research, composite restorations continues to have higher failure rates [1,2]. These failures have been observed mainly at the gingival margins of preparations for adhesive restorations, where the substrate is the dentin/cement junction [1]. If not performed correctly, the total-etch technique can result in an excessive etching and formation of a deep zone of demineralized dentin; the adhesive may not infiltrate throughout the entire decalcified area, originating a hybrid layer with regions of exposed collagen fibers more susceptible to hydrolysis (weak zone) [3]. Excessive drying of dentin substrate after etching may lead to the collapse of collagen fibers, on the other hand, excess residual water on it may contribute to separation of the adhesive phases promote longitudinal degradation of the restoration [4].

Self-etching adhesives are composed of acidic resin monomers that simultaneously promote superficial dentin demineralization and resin adhesive infiltration into the dentin tissue [5]. These adhesive reduce the possibility of weak zone formation, the clinical steps, and the technique sensitivity as regards maintenance of dentin humidity [6]. However, the hydrophilic nature of the total-etching and self-etching adhesives can increase water sorption and permeability of resin–dentine interfaces, contributing to their hydrolytic instability after aging in water, promoting longitudinal adverse effects [7]. Therefore, the longevity of hybrid layer has been still widely questioned as a consequence of hydrolysis of the adhesive interface over time.

New alternatives are being exhaustively studied to develop durable dentin bonding pattern. In 1999, Gonçalves et al. [8] developed an Nd:YLF(yttrium-lithium-fluoride) Laser irradiation technique on dentin, after phosphoric acid etching and adhesive application, however, prior to adhesive polymerization. The authors observed the fusion and recrystallization of dentinal hydroxyapatite in the presence of resin monomers, resulting in a more resistant substrate and increase in bond strength. Afterwards, various authors also observed that Nd:YAG Laser irradiation on dentin impregnated with non polymerized adhesive significantly increased the immediate bond strength [9-14], and could consequently optimize the restoration longevity. Therefore, longitudinal evaluation of the bond strength using this technique has become of primordial importance.

Thus, the aim of this study was to evaluate in vitro, the influence of Nd:YAG laser on the microtensile bond strength to dentin of a two-step total-etch and a two-step self-etch adhesives when the laser was applied on the unpolymerized adhesives, at time intervals of 24 h and after a 1-year period of storage. This study tested three null hypotheses: 1) the adhesive systems tested can achieve similar bond strengths to dentin; 2) Nd:YAG Laser irradiation through unpolymerized adhesives does not affect bond strength to dentin; 3) the storage period does not affect the bonding effectiveness of etch-and-rinse and self-etch adhesives to dentin.

MATERIALS AND METHODS

• One-hundred and twenty freshly extracted bovine incisor teeth bovine were used in this study. An area of flat dentin was obtained as described by Barcellos et al. [15]. The smear layer was standardized using 600 grit abrasive papers coupled to a circular polishing machine, under water cooling.

• The teeth were divided into 4 groups (n = 30), according to the surface treatment performed:

• Group 1 (Control): The surfaces were etched for 15 s with 37% phosphoric acid gel, rinsed and the excess moisture was removed with absorbent paper. Single Bond/SB total-etch adhesive (3M ESPE, St. Paul, MN, USA) were applied according manufacturer's instructons. The adhesive was light activated for 10 s (LED light unit Emitter A, Schuster, Santa Maria, RS, Brazil) with power density of 600 mW/cm^2.

• Group 2 (Control): Clearfil SE Bond/CL self-etch adhesive (Kuraray Medical Inc, Tokyo, Japan) were applied according manufacturer's instructons. The adhesive was light activated for 10 s.

• Group 3 (Experimental/Laser): The surfaces received the application of SB total-etch adhesive (3M ESPE), following the same protocol utilized for Group 1. Before light polymerization, the surfaces were irradiated with Nd:YAG laser. The adhesive was light activated for 10 s.

• Group 4 (Experimental/Laser): The surfaces received the application of CL self-etch adhesive (Kuraray), following the same protocol utilized for Group 2. Before light polymerization, the surfaces were irradiated with Nd:YAG laser and the adhesive was light activated for 10 s.

Treatment with Nd:YAG laser

It was used the Nd:YAG laser (Laser Pulse Master 600 iQ/American Dental Technologies Inc, TX, Corpus Christi, USA) at a wavelength of 1.064 μm. The parameters used were: output energy - 120mJ per pulse; pulse repetition rate - 10 pulses per second (10 Hz); pulse width – 10 ns. The Nd:YAG laser was fitted with a non contact tip 320 μm in diameter, applied freehand by one calibrated operator, in non-contact mode, and scanning over a 5 mm X 5 mm area of flat dentin for 60 s. The energy density (ED) was 149.28 J/cm^2. During laser application the laser tip was at a 90º angle, perpendicular and to the surface and at a distance of 1 mm from it [9-12] in a focused mode.

Restoration placement

Composite resin blocks (Filtek Z350, 3M ESPE), approximately 4 mm high were built on the treated surfaces. Each 2 mm portion was light activated for 40 s (LED light unit Emitter A, power density = 600 mW/cm^2).

The bonded teeth were stored in distilled water at 37ºC, for time intervals of 24 h or 12 months [16-19]. The water was changed every week during the course of 1 year [20].

Microtensile Bond Strength Test

The test specimens were cut into parallel sections to the long axis of the tooth measuring approximately 1 mm as described by Barcellos et al.[15]. The sticks were attached to a microtensile device in a universal testing machine (DL-1000, EMIC, São José dos Pinhais, PR, Brazil), with a 10 kg load cell, at a cross-head speed of 0.5 mm/min, in accordance with the ISO 11405 Standard. The bond strength data were expressed in Megapascals (MPa).

After the microtensile test, the specimens were analyzed with a 20x stereomicroscope (Stemi 2000 - Karl Zeiss, Germany). Fractures were classified as: cohesive in the substrate, cohesive in the composite, adhesive or mixed.

Statistical Analysis

To the pre-test failures (PTFs), the lowest measured value was assigned. Cohesive failures were discarded [20]. The mean value for the sticks originating from each tooth was calculated and used for the statistical analysis.

Data, expressed in megapascal (MPa), were analyzed by three-way ANOVA (adhesive, technique and storage time) followed by Tukey test (α 5%).

Scanning electron microscopy (SEM) examination

Two teeth from each group were prepared for SEM analysis (high vacuum, 15KV, Everhart-Thornley Detector - ETD), according to Marimoto et al. [14].

RESULTS

SB total-etch adhesive presented higher bon strength values compared with CESB self-etch adhesive (p = 0.0049), the unlased surface treatment presented higher bond strength values compared with lased surface treatment (p = 0.0000) and storage in water for 24 h presented higher bond strength values compared with storage in water for 12 months (p = 0.0001).

Table 1 shows the results of the Tukey test for the interaction between the factors "technique" and "storage time" (p=0.0000).

Table 1 - Results of Tukey Test (5%) for interaction between factors Technique X Storage Time

TECHNIQUE	STORAGE TIME	MEAN ± S-D	HOMOGENEOUS GROUPS	
Control	24 h	33.09 ± 5.70	A	
Control	Longitudinal	29.99 ± 5.47	A	
Laser	24 h	29.22 ± 7.27	A	
Laser	Longitudinal	17.70 ± 5.64		B

LEGENDS: S-D = Standard Deviation.
Means followed by the same letters do not differ statistically among them (p > 0.05).

The technique of irradiating the tissue with Nd:YAG laser in the time interval of 12 months storage) presented significantly lower bond strength when compared with the technique of irradiating the tissue with Nd:YAG laser storage in water for 24 h and the control technique, irrespective of the storage time.

Table 2 shows the results of the Tukey test for the interaction between the factors "adhesive", "technique" and "storage time" (p = 0.0285). The Nd:YAG laser technique for 12 months storage presented significantly lower bond strength when compared with the Nd:YAG

Table 2 - Results of Tukey Test (5%) for interaction between factors AdhesiveXTechnique X Storage Time

Adhesive	Technique	Storage Time	Mean ± S-D	Homogeneous Groups		
Single Bond	Control	24 h	34.05 ± 6.14	A		
Clearfil SE Bond	Control	24 h	32.12 ± 5.26	A		
Single Bond	Laser	24 h	30.54 ± 5.94	A		
Clearfil SE Bond	Laser	24 h	29.45 ± 5.11	A		
Single Bond	Control	Longitudinal	29.36 ± 5.57	A		
Clearfil SE Bond	Control	Longitudinal	29.09 ± 8.84	A		
Single Bond	Laser	Longitudinal	22.06 ± 3.77		B	
Clearfil SE Bond	Laser	Longitudinal	13.35 ± 3.35			C

LEGENDS: S-D = Standard Deviation.
Means followed by the same letters do not differ statistically among them (p > 0.05).

laser technique of 24 h storage and the control technique, irrespective of the storage time. The Nd:YAG laser technique for 12 months water storage presented significantly lower bond strength for the CSEB when compared with the SB.

For the fracture type, it was observed an increase in the occurrence of adhesive fractures in the time interval of 12 months, being more pronounced for the technique of Nd:YAG laser technique compared to control technique.

Figures 1 and 2 show SEM images obtained of the interfaces created in the all groups.

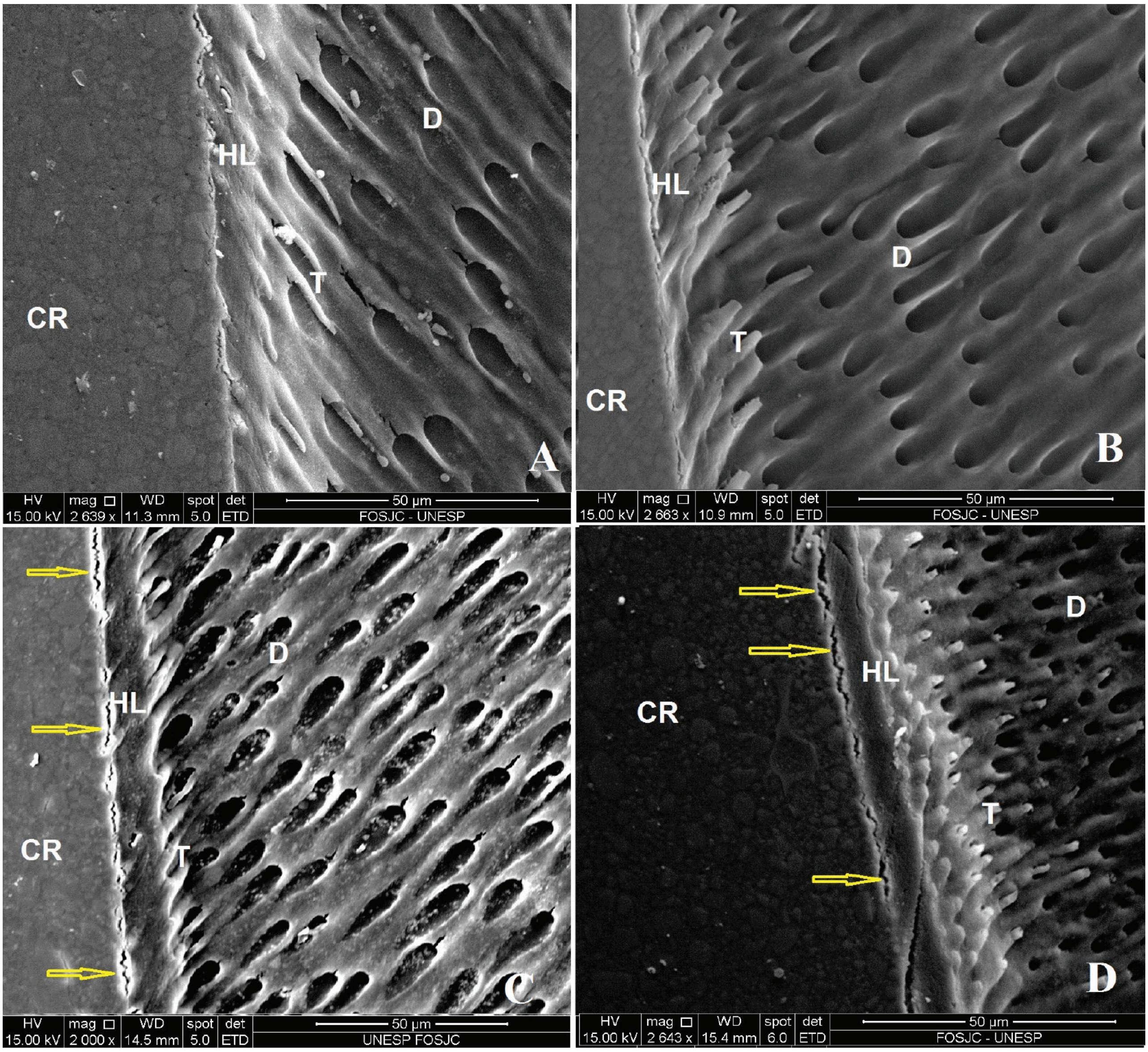

Figure 1 - A and B – Hybrid layer that received SB and CL, respectively by control technique and storage for 24 h; a typical hybrid layer was created; C and D - Hybrid layer that received SB and CL, respectively by control technique and storage for 12 months. Some areas with the presence of gaps in the bond interface were observed (arrow). (Legends: CR – Composite resin; HL – Hybrid Layer; T – Tags: D – Dentin.)

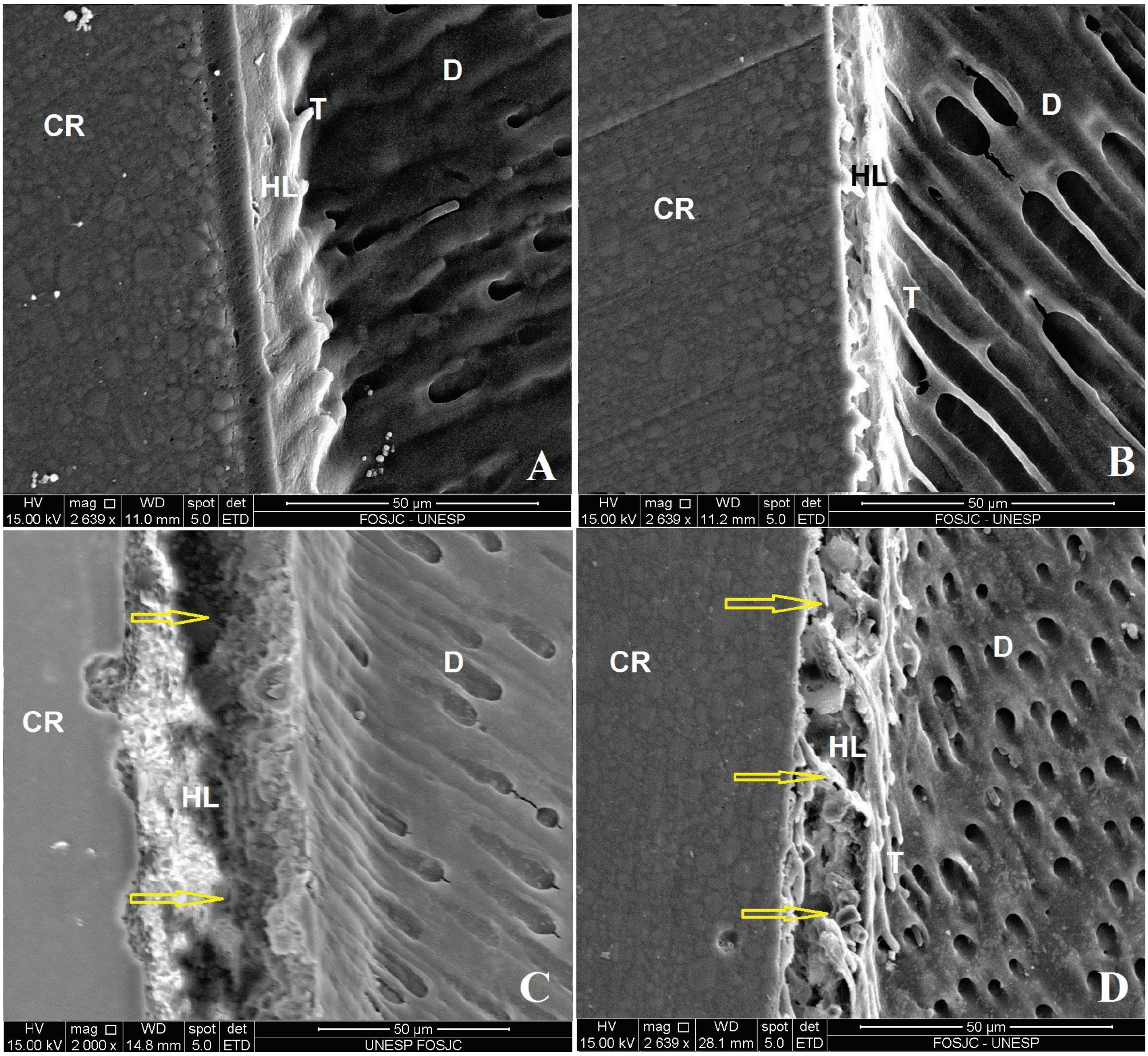

Figure 2 - A and B – Hybrid layer that received SB and CL, respectively by experimental/Laser technique and storage for 24 h. Interface micromorphology and hybrid layer thickness differ from those seen previously. Interface with characteristic of fusion of superficial dentin impregnated with adhesive due to irradiation with Laser (Fig. A). Interface with presence of gaps between resin and adhesive (Fig. B). C and D - Hybrid layer that received SB and CL, respectively by experimental/Laser technique and storage for 12 months. Adhesive resin or the hybrid layer were lost during 1 year of water immersion (Fig. C). No evidence was found of hybrid layer formation, this being replaced by presence of molten mass and presence of cracks and gaps, probably due to effects of water storage for 12 months (arrows) (Fig. D). (Legends: CR – Composite resin; HL – Hybrid Layer; T – Tags: D – Dentin.)

DISCUSSION

In this study, it was used indirect storage technique (storage of restored teeth) for evaluating the longitudinal dentin bond strength, based on previous studies [16-19]. In order to accelerate the hydrolysis of the adhesive interface during the 12 months of indirect storage and observe possible statistical differences between the variables tested, the restored teeth were subjected to weekly changes of the storage medium, which can induce calcium loss [20]. When there is no exchange of storage media, there is a balance transfer of calcium ions between the substrate and the solution storage unchanged, reducing the longitudinal degradation [20].

The parameters of Nd:YAG laser used in this study was based in previous studies [12-14] that used high energy densities for irradiation on dentin impregnated with non-polymerized adhesives, and that observed increase of imediatte bond strength. Therefore, it was used a high ED (149.28 J/cm^2) of Nd: YAG laser with the purpose to find favorable results of longitudinal microtensile bond strength using this technique.

The first null hypothesis was rejected, because the results of the present research showed the superiority of the SB total-etch adhesive compare to the CSEB self-etching adhesive. Previous studies have shown that the SB led to better results of bond strength to dentin, when compared with the CSEB [7,22]. The total-etch completely removes the smear layers and demineralizes the dentin to a depth of 3.0 – 7.0 um, depending on the concentration, pH, viscosity and time of duration of conditioning. After acid etching the collagen network with low mineral content is exposed, allowing the infiltration of resin through the nanometric spaces [22]. This allows strong micro-mechanical interlocking between the adhesive and dentin, leading to high bond strength values [22,23].

The SB is composed of a mixture based on 2- hydroxyethyl methacrylate (HEMA)/ Ethanol, capable of wetting the etched dentin surface and keep the collagen fibers expanded after evaporation of the solvents, improving the infiltration of the monomers [7,24]. This efficacy may be increased due to the presence of the acid carboxylic groups in it [7]. The total-etch technique continues to be the one most frequently used by clinicians, because even with the improvements in self-etching adhesives, the results in the literature are still very controversial with regard to their clinical longitudinal effectiveness.

The second null hypothesis was accepted for the short-time evaluation, however, it was rejected for the long-term evaluation, because the control technique presented higher bond strength values compared with the Nd:YAG laser technique. The results of this study are in agreement with the findings of Castro et al. [24], who observed that irradiation with Nd:YAG laser at the EDs of 93.30 J/cm^2 and 124.4 J/cm^2 on dentin impregnated with SB, and before it was light activated, did not improve the microtensile bond strength. Authors [24] believe that SB does not absorb wavelengths between 950 and 1100 nm, which includes the wavelength of 1064 nm emitted by Nd:YAG laser. The absorption spectra of SB and CSEB adhesives is between 400 and 550 nm. As Nd:YAG laser changes the tissue only when absorbed, this adhesive probably did not undergo any change from the direct action of Laser. Moreover, Arrais et al. [25] observed that the SB and CSEB adhesives present absorption spectra of a similar spectral band between them. Maybe CSEB have presented a similar behavior of the SB with regard to the non absorption of the wavelength emitted by Nd:YAG laser.

Therefore, if the laser energy is not absorbed by the adhesive systems, it will spread into the underlying tissue. Therefore, photothermal effects are expected to occur on dentin surface. Previous studies showed that lower EDs of Nd:YAG laser than that used in this study (149.28 J/cm^2) promoted morphological and chemical alterations on the dentin surface. Rohanizadeh et al. [26], using an ED = 40.74 J/cm^2 of Nd:YAG laser on dentin, observed the formation of a rough, melted and recrystallized surface. Ferreira et al. [27] observed that an ED $\geq$ 56.68 J/cm^2 promoted the formation of cracks on the dentin surface and tissue vitrification. Yamada et al. [28] observed the formation of melted globules on the dentin surface irradiated with Nd:YAG laser of an ED = 19.10J/cm^2. Therefore, maybe the photothermal effects promoted by Nd:YAG laser, which chemically and morphologically change the superficial dentin impregnated with adhesive systems and consequently the hybrid layer (Figure 2A), also promote the formation of cracks, bubbles, carbonization, fusion and recrystallization of this substrate (Figure 2B). These effects negatively influence the bond strength, when compared with the control technique.

Furthermore, intertubular dentin is mainly composed of collagen. The acid etching of dentin exposes the collagen fibers, allowing the infiltration of resin monomers and formation of interlocking at molecular level of these monomers within the collagen network, this union being one of the factors responsible for the bond strength and clinical performance of adhesive restorations [29]. Consequently, the hybrid layer is predominantly composed of collagen fibers and resin monomers infiltrated into the interfibrillar spaces [30]. Yamada et al. [28] observed that an ED = 19.10 J/cm^2 of Nd:YAG laser promoted the disappearance of collagen from superficial dentin, suggesting that irradiation instantly heats the dentin surface to high temperatures, carbonizing the collagen and other proteins on this surface. Therefore, it maybe speculated that the photothermal effect of Nd:YAG laser, promoting elevation of the surface temperature of irradiated dentin may have caused the complete denaturation or carbonization of the collagen, and a possible negative influence on the formation of interlocking of the resin monomers within the collagen network, decreasing the bond strength in comparison with the control group

The third null hypothesis was rejected, because the storage time of 24 h presented higher bond strength values in comparison with the storage time of 12 months. These results are in agreement with various studies [7,31-33] that observed a reduction in dentin bond strength for the SB and CSEB when storage in water for 12 months, due to degradation of the hybrid layer (Figure 1C and 1D).

There are many factors that can trigger the degradation of the hybrid layer, and consequently, reduce its longevity: (1) dentine has proteolytic enzymes, also called matrix metalloproteinases (MMPs) that can be activated by acid etching during adhesive procedure [34], and are responsible for rapidly degrade denatured collagen which were left unprotected after the process of demineralization by acid etching and not infiltrated by the adhesive monomers; (2) the incomplete polymerization of infiltrated monomers can affect the longitudinal mechanical and chemical stability of the adhesive interface [35];(3) the presence of residual solvents may contribute to the formation of a hypertonic zone at the bond interface, increasing its hydrophilicity and accelerating the degradation process [36]; (4) The water present in the saliva, in the intrinsic humidity of dentin (dentinal fluid) [4], in the adhesive systems [22], in the humid technique of adhesive system application, in the hydrophilic character of adhesive systems plays a role in solubilizing the resin polymers, separating the polymeric chains and reducing the physical and mechanical properties of the adhesive system at the bond interface [4,31]; (5) saliva has proteolytic enzymes capable of degrading the collagen fibers unprotected and not infiltrated by the adhesive monomers [24].

For the interaction between the factors “Technique” and “Storage time”, the Nd:YAG laser stored for 12 months presented significantly lower bond strength values when compared with the Nd:YAG laser technique stored for 24 h and with the control technique, irrespective of the storage time. Probably the low absorption and high penetration of Nd:YAG Laser can lead to morphological and chemical changes on dentin that are not favorable for adhesion, not compromising the immediate bond strength but the long-term evaluation.

The images obtained by SEM clearly demonstrated the degradation of the hybrid layer, and loss of initial morphology of the samples irradiated with Nd:YAG laser, after storage in water for 12 months. In Figure 2C the solubilization or dissolution of organic material may be observed, probably due to the separation of the peptide chains of the collagen fibers, due to protein denaturing [37] or due to carbonization and complete disappearance of these fibers [28] promoted by the elevation of temperature at the irradiated dentin surface, and consequently, degradation of the hybrid layer formed by SB. Figure 2D illustrates the morphological change in the hybrid layer formed by the irradiated CSEB, due to the dissolution of water, with an aspect of melted and fused mass, in addition to the presence of cracks and gaps. These morphological and chemical changes in the dentin surface due to the photothermal effects of Nd:YAG laser [26,38] may have promoted the formation of an even weaker bond interface, with a negative influence on the bond process in comparison with the control technique.

For the interaction between the factors "Adhesive, Technique and Storage Time", the group in which the CSEB was used submitted to Nd:YAG laser technique and storage for 12 months presented the lowest bond strength values, in agreement with the images obtained by SEM (Figure 2D). The bond interface presents an aspect of melted and hydrolyzed mass, with the presence of gaps due degradation of the bond interface.

Furthermore, SB associated with the Nd:YAG laser technique and 12 months of water storage, presented lower bond strength values when compared with the other groups, except for the group in which CSEB with the Nd:YAG laser technique and 12 months of water storage. This may be result of the chemical nature of the CSEB. In addition, the total-etch adhesives promote a thicker hybrid layer (around 4.2 μm), when compared with mild self-etching adhesives, such as CSEB (0.7 – 1.5 μm) [23], as may be observed in Figures 1A and 1B. Maybe the photothermal effects of Nd:YAG Laser have presented greater intensity in the formation of the hybrid layer for CSEB, due to its thinner thickness, negatively influencing the bond strength when compared with SB.

Moreover, the Nd:YAG laser technique, for both adhesives, presented lower bond strength for 12 months water storage when compared to 24 h water storage. The photothermal effects of Nd:YAG laser may have caused morphological and chemical alterations in the superficial dentin promoting the denaturation or carbonization of the collagen [28,39,40] and increased its susceptibility to longitudinal degradation.

In conclusion, these parameters used in this study promoted negative photothermal effects on the bond interface. The solution for this inconvenience could be in the choice of parameters with lower frequency and energy density, which did not cause alterations by overheating, by the longer time of relaxation between the pulses.

Future studies are important to elucidate the effects of Nd:YAG laser on dentin with non-polymerized adhesive, including Transmission Electron Microscopy (TEM) and/or Fourier Transform Infrared Spectroscopy (FTIR) analysis. Also, further "in vitro" studies are necessary to observe the longitudinal bond strength using the Nd:YAG laser technique with different parameters from those used in this study.Reduced parameters may change dental tissues without promoting photothermal effects. In addition, studies that simulate the pulp pressure should be conducted, which may offer cooling and reduction of thermal effects during laser irradiation on the tissue.

CONCLUSION

According to the methodology used, and based on the results obtained, we may conclude that:

- The adhesive systems tested showed similar bond strengths to dentin;
- Nd:YAG laser irradiation through unpolymerized adhesives affects bond strength to dentin;
- The 12 months water storage period affects the effectiveness of adhesive bonds to dentin;

• When the control technique was used, the adhesive systems showed no reduction in bond strength after 12 months water storage;

• When dentin that was irradiated with Nd:YAG laser through the unpolymerized adhesives was stored in water for 12 months, the bond strength decreased;

• Laser irradiation of dentin through the unpolymerized self-etch adhesive significantly reduced bond strength in comparison with total-etch adhesive, after 12 months water storage.

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