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ORIGINAL RESEARCH

Evaluation of the Influence of the Nd:YAG Laser and Different Irrigants on the Bond Strength of the Adhesion of the Fiber Posts to Root Dentin using a Self-etching Adhesive System

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ABSTRACT

Aim: The aim of this study was to investigate the effects of pretreatment of different irrigating solutions with and without the application the Nd: YAG laser on the bond strength (RU) of the adhesion of the fiberglass post relined with resin composite to the root dentin.

Materials and methods: Sixty-six single bovine incisor roots were divided into 6 groups according to irrigating solution and with/without the apllication of the Nd: YAG laser after root canal filling: S—saline; C—2% chlorhexidine solution, H—2.5% sodium hypochlorite; SL—saline + laser, CL—2% chlorhexidine + laser; HL—2.5% sodium hypochlorite + laser (all n = 11). The roots were standardized up to a file # 80 and root-filled with gutta-percha (Dentsply) and Sealer 26 (Dentsply) by lateral condensation. The root canal filling was partly removed. Afterward, root canals were irrigated with 5 ml of the selected irrigant and the fiberglass post were cemented with epoxy resin curing dual Bifix QM (VOCO) and a self-etch adhesive system Futurabond DC (VOCO). All roots were sectioned transversely, and the push-out tested was performed. The bond strength means were analyzed by the analysis of variance and Tukey test (α = 5%).

Results: The following bond strength MPa values—were recorded for each group: group C—7.77(±1.8)^a, LC—6.46 (±2.2)^a, S7.33 (±2.2)^a, LS 7.35 (±1.68)^a, H 5.43 (±1,3)^b, LH 5.13 (±1,6)^b. A signifcant bond strenght decrease was noticed with the use of 2.5% NaOCl ($p < 0.05$). No statistical significant difference were found with our without the apllication of the Nd:YAG laser ($p > 0.05$).

Conclusion: Regardless the irrigant tested, the use of Nd: YAG laser can be indicated prior to cementation of fiberglass without loss in bond strength.

Keywords: Bond strength, Fiberglass post, Chlorhexidine, Sodium hypochlorite, Laser Nd:YAG.

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INTRODUCTION

The restorative treatments have evolved considerably with the possibility of adhesivity of dental materials to the mineralized dental tissues. The fiberglass post possess elastic modulus close to that of dentin, carrying less unwanted consequences to root, i.e. root fracture.[1,2] However, there are much discussion about the efficiency of adhesivity resin cements and adhesives respective systems on intracanal dentin.[3]

One of the main concerns of adhesive systems is the action of light curing units that can be achieved inside the root canal. For instance, the use of cements relying on chemical polymerization or showing 'dual' polymerization seems to ensure a better curing of the cement.[4] In addition, the use of translucents posts—which allows the transmission of light through the fibers—permit the use of light curing units in space ready for the pin.[5]

The adhesivity of fiberglass posts to dentin is directly implicated to the type of treatment applied to respective dentin.[5] The implications of irrigants used during endodontic treatment as well as the application of alternative treatment protocols has been currently discussed in the literature. The sodium hypochlorite (NaOCl) – the most commonly irrigant used in endodontic treatment—diamond antimicrobial broad-spectrum activity and the ability to dissolve organic matter and necrotic tissue.[6-8] Chlorhexidine digluconate (CHX) has been suggested as an irrigant in endodontic treatment because its antimicrobial activity does not affect the bond strength of resin composite restorations to the coronal dentin or the root canal.[9,10] Moreover, it substantivity because its bactericidal action persists in the channel for 12 weeks after its use as irrigating solution.[11,12]

Nowadays, new techniques have been developed in an attempt to avoid thermal damage, improve adhesion, and simplify clinical bonding procedures. Two main technological research fields drive this evolution: (1) new adhesive systems and (2) the use of different lasers. With the development of adhesive materials became increasingly clear that the removal or modification of smear layer is essential for the formation of a hybrid layer quality.[2-13] It is known that the application of Nd: YAG on dentin promotes fusion of dentin tubules.[14]

Therefore, the aim of this study was to investigate the effects of pretreatment of different irrigating solutions with and without the application the Nd: YAG laser on the bond

strength (RU) of the adhesion of the fiberglass post relined with resin composite to the root dentin.

MATERIALS AND METHODS

Sixty-six freshly extracted bovine incisors with anatomically similar root segments and fully developed root were selected. Teeth were stored in 0.02% thymol solution and prepared within 1 month of extraction. Each tooth was decoronated below the cementoenamel junction perpendicular to the longitudinal axis using a slow-speed, water-cooled diamond disk (90 µm- Microdont) at low rotation. The roots were cut in a uniform length of 16 mm from the apical end. The apexes of the teeth were sealed with a temporary filling material (Cavit W; Premier Dental Produtos, Rio de Janeiro, RJ, Brazil).

All root canals were prepared by one trained operator. Pulp tissue and predentin were removed, and the root canals were enlarged up to #80 file (Maillefer). The apical end (1 mm) was left unprepared to prevent the apical extrusion of solutions and luting cement. Roots were rinsed with 5 ml physiologic saline solution to remove the remaining debris, drieded with paper points, and root-filled with gutta-percha (Dentsply Ind. E Com Ltd) by lateral condensation and Sealer 26 (Dentsply De Trey, Konstanz, Germany). The specimens were kept at 37°C and relative humidity for 7 days, for total cement setting shutter.

The specimens were fixed in colorless acrylic resin (Jet, Artigos Odontológicos Clássicos, São Paulo, SP, Brazil) through their apical 3 mm. During this procedure, the teeth were kept perpendicular to the ground, according to the following protocol: (a) drill the respective pin system used was placed on the vertical rod and movable in the channel liner prepared, (b) the long axes of the drill bit, the teeth and the vertical rod movable liner remained parallel to each other, (c) the acrylic resin was manipulated and poured into the silicone mold, (d) the assembly rod/drill/tooth was lowered to the marking of 3 mm and fixed in acrylic resin. After, the filled was partially removed, remaining 3 ± 1 mm of filling material from the root apex. Drills pin system fiberglass (FGM - White Post DC3 or DC4), consistent with the size of the root canal were used.

Afterward, the specimens were then divided into 6 groups were divided into 6 groups according to irrigating solution and with/without the application of the Nd: YAG laser after root canal filling: YAG laser: S—saline; C—2% chlorhexidine solution, H – 2.5% sodium hypochlorite; SL—saline + laser, CL—2% chlorhexidine + laser; HL – 2.5% sodium hypochlorite + laser (all, n = 11).

In the following, the canals were irrigated with 5 ml of the irrigant solution according to the irrigants tested, and the laser was applied in the selected groups (LS, LC and LH). The handset light laser Nd: YAG - 300-D laser American Dental Technologies, pulsed, high power was used. The irradiation was set for 100 mJ energy, repetition rate (frequency) of 15 Hz and maximum power of 1.5 W. For the guidance of the laser light used a light guide, the Helium Neon laser of low intensity (with a wavelength of 632.8 nm). The delivery system was used for optical fiber with 0.32 mm in diameter, by contact, with the tip of the fiber where the interaction occurring tissue. The laser application was performed introducing the optical fiber in the total length of the root canal apex radiating to the cervical region the entire length of the root canal in a straight helical for 5 to 7 seconds. This procedure was repeated for four times, giving a total time of about 20 s, at a rate of 2 mm/s.

The canals were dried with paper points. Then, the adhesive system with polymerization dual Futurabond DC (VOCO) was applied with a microbrush, massaging the walls for 20 seconds. The solvent was dispersed with air for 5 seconds. According to the manufacturer's recommendation adhesive layer was not polymerized. The system cementing based epoxy resin curing dual Bifix QM (VOCO) was applied using the mixing tip root of the double syringe. The cement was injected in the root starting from their apical end and continuing toward the root canal. Then the cement was applied into the root canal and the pin was placed on the canal by ensuring that there was a slight excess. The pin was held in place with firm pressure for 5 to 10 seconds, and the photopolymerization was applied for 40 seconds by placing the light guide toward the pin. The specimens were kept at 37°C and relative humidity for 7 days.

The specimens were fixed to cutting in machine LabCut 1010 (EXTEC-ERIOS, São Paulo, SP, Brazil) and sectioned transversely to the long axis of the root with diamond disk (EXTEC -ERIOS) under constant water cooling. The first cervical slice, ~ 1 mm thick was discarded. From each specimen three slices of approximately 2 mm thickness was selected for the push-out test. Before the test, the diameters of the set post/cements and height of the specimen were measured with a digital caliper (Starret® 727, Starret, Itu, Brazil).

The push-out test was performed on a universal testing machine EMIC model DI-1000 (EMIC - Curitiba - Brazil) with a speed of 1 mm/min—1 and 50 kgf load cell. Care was also taken to ensure that the contact between the punch tip and post section occurred over the most extended possible area to avoid any notching effect of the punch tip into the post surface.

To express the bond strength in megapascals (MPa), the following formula were used: O = C/A, where C = load to break the specimen (kgf) and A = interfacial area (mm^2). So A = π.g. (R1 + R2), where A = interfacial area, π = 3.14, g = generatrix of the trunk, R1 = smallest radius of the base, R2 = radius of the larger base, h = height of the section. To calculate the generatrix of the trunk will be used $g^2 = h + [R2R1]$.[2] The result of the O bond strength, initially kgf/mm^2, was transformed to MPa, multiplying the value of O for 10, considering the following measures Match: 1 kgf/mm^2 = 10N/mm^2 = 10 MPa.

The means and standard deviations of bond strength were calculated, and the data were analyzed using analysis of variance and the Tukey test for post hoc comparisons (a = 0.05).

RESULTS

The mean and standard deviation of the push-out test, showing the bond strength values for each group are shown in Table 1. The statistical analysis of the data revealed a significant bond strenght decrease after the use of 2.5% NaOCl on dentin as irrigant ($p < 0.05$) No statistical significant difference were found with our without the application of the Nd: YAG laser ($p > 0.05$).

DISCUSSION

Data obtained in the present study revealed that the bond strenght is significantly decreased after the use of 2.5% NaOCl when compared to other irrigants commonly used in endodontic treatment. Additionally, the apllication of the Nd: YAG laser does not seem to significantly improve the bond strength of the adhesion of the fiber posts to root dentin using a self-etching adhesive system.

The selection for bovine teeth was based on studies showing that the structure of bovine-dentin is a valid alternative due to the morphological and histological similarities exist.[15] Also, because others advantages such as ease of being achieved in shambles, having large sizes as well as large surfaces.[14]

Previous studies have indicated that the loss of the integrity of resin-dentin bonds overtime is likely the combined effect of hydrolytic deterioration of resinous componentes after water sorption and the degradation of denunded collagen fibrils exposed to incompletely infiltrated hybrid layers. The implications of irrigants used during endodontic treatment as well as the application of alternative treatment protocols has been currently discussed in the literature.

Table 1: Bond strength mean (MPa) and standard deviation (±) according to treatments

Irrigating solutions	*Treatment of dentin*	
	Without laser	*With laser*
Saline	7.33 ± 2.29[a]	7.35 ± 1.68[a]
Chlorhexidine	7.77 ± 1.83[a]	6.46 ± 2.26[a]
NaOCl	5.43 ± 1.39[b]	5.13 ± 1.68[b]

Different superscript letters indicate statistically significant differences respecting the irrigants ($p < 0.05$)

In this study, the use of NaOCl significantly decreased the bond strength of the adhesion of the fiber posts to root dentin using a self-etching adhesive system when compared to all other irrigant tested. This fact might be attributed to the ability of sodium hypochlorite lead to oxidation of the collagen fibrilis that seems critical for the initiation of the polymerization.[16-18]

Currently, the chlorhexidine digluconate—suggested as an irrigant in endodontic treatment because its antimicrobial activity—showed no interference on the bond strength of the adhesion of the fiber posts to root dentin using a self-etching adhesive system. Erdemir et al (2004),[18] found that root canal irrigation with chlorhexidine gluconate 0.2% increases the bond strength to dentin due to its adsorption ability—positevely ionic with affinity to negatively charged substrates such as dentin. Thus, Santos et al (2006)[19] concluded that there was a significant decrease in bond strength associated to NaOCl, whereas chlorhexidine irrigation showed no effects on adhesion. It was concluded that endodontic irrigants affected differently bond strength to pulp chamber dentin. Moreover, Moreira et al[20] reported that the CHX is an auxiliary chemical substance that does not interfere with collagen present in the organic matrix of root dentin; thus, it maintains the quality of the dentin substrate for posterior obturation or restoration of the tooth with resin-based materials.

Adhesive systems have evolved in the course of several generations the traditional application of the conditioner, primer, and adhesive in three stages has been replaced by the following three different product categories: (1) adhesive systems in which the primer and the adhesive are applied simultaneously after acid etching; (2) the self-etching primers, in which the acid-etching stage and the primer take place at the same time, followed by the application of the adhesive; and (3) the self-etching adhesives that are characterized by the acid etching, primer and adhesives stages occurring at the same time. With new self-etching adhesive systems, the dentinal smear layer is no longer completely eliminated but treated like a substrate.

In the present study, the Nd:YAG tested were introduced into dentistry specifically as an alternative to traditional mechanical instrumentation for tooth structure preparation.

Although, most researchers have found significantly higher bond strength values for adhesive systems that received Nd:YAG irradiation prior to polymerization,

controversy exhists on wether Nd:YAG is able to improve the bond strengh values of adhesive systems. In the present study, regardless the irrigant tested, the use of Nd:YAG laser did not significantly the bond strength of the adhesion of the fiber posts to root dentin using a self-etching adhesive system. Lee et al (2002) investigated the ability of the laser Nd:YAG in causing the reduction of dentin permeability, which theoretically would be important to the success of endodontic treatment. The authors concluded that laser irradiation can be used to reduce dentinal permeability, which would allow better sealing and thus reduce the risk of another infiltration by microorganisms.[14] Nagasse et al (2010) compared the adhesive strength of retainers cemented channels in previously irradiated by laser. The results showed no statistically significant differences between groups. The authors thus concluded that both the use of the Er,Cr:YSGG laser and the Nd:YAG associated with the Er,Cr:YSGG not affect the retention of fiber posts cemented in bovine teeth.[21] These findings corroborate the results shown in our research where we found that morphological changes caused by laser irradiation on root dentin were not able to improve or worsen the adhesion of resin cement/pin to the root canal.

Overall, the present study revealed that the bond strenght is significantly decreased after the use of 2.5% NaOCl when compared to other irrigants commonly used in endodontic treatment. Additionally, the apllication of the Nd: YAG laser does not seem to significantly improve the bond strength of the adhesion of the fiber posts to root dentin using a self-etching adhesive system.

CONCLUSION

Regardless the irrigant tested, the use of Nd:YAG laser can be indicated prior to cementation of fiberglass without loss in bond strength. The use of sodium hypochlorite decreased bond strength independently the use of laser.

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