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Shear bond strength of orthodontic tubes bonded directly with composite resinreinforcement on the enamel surface

Resistência ao cisalhamento de tubos ortodônticos colados diretamente com reforço de resina composta na superfície de esmalte

Resistencia al corte de los tubos de ortodoncia unidos directamente con refuerzo de resina compuesta

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Tainah Oliveira Rifane
ORCID: https://orcid.org/0000-0001-6120-1672
Faculdade Paulo Picanço, Brazil
E-mail: tainah08@gmail.com
Italo Hudson Tavares Maia
ORCID: https://orcid.org/0000-0003-4274-115X
Faculdade Paulo Picanço, Brazil
E-mail: italohudson98@hotmail.com
Andressa Silva de Oliveira
ORCID: https://orcid.org/0000-0001-9015-844X
Faculdade Paulo Picanço, Brazil
E-mail: andressa_oliveira21@outlook.com
Ranyele Elis Alexandre Rodrigues
ORCID: https://orcid.org/0000-0001-6437-208X
Faculdade Paulo Picanço, Brazil
Email: ranylily.rr@gmail.com
Francisbênia Alves Silvestre
ORCID: https://orcid.org/0000-0001-8620-8678
Faculdade Paulo Picanço, Brazil
Email: beninha00@hotmail.com
Manuela Timbó Farrapo
ORCID: https://orcid.org/0000-0003-4480-4214
Faculdade Paulo Picanço, Brazil
E-mail: manuela.timbo@hotmail.com
Nara Juliana Custódio de Sena
ORCID: https://orcid.org/0000-0002-3924-477X
Universidade Federal do Ceará, Brazil
E-mail: narajuliana@gmail.com
Felipe Franco Marçal
ORCID: https://orcid.org/0000-0003-3227-9889
Clínica Escola Odontologia Unichristus, Brazil
E-mail: felipef.marçal@gmail.com
Lara Ferreira Barroso
ORCID: https://orcid.org/0000-0001-7022-2571
Faculdade Paulo Picanço, Brazil
Email: laraferreira2508.@gmail.com
Samara Tábata Cavalcante Braga Medeiros
ORCID: https://orcid.org/0000-0003-0650-7307
Faculdade Paulo Picanço, Brazil
E-mail: samaratabatacavalcante@hotmail.com
Victor Pinheiro Feitosa
ORCID: https://orcid.org/0000-0001-8795-9967
Faculdade Paulo Picanço, Brazil
E-mail: victor.feitosa@facpp.edu.br

Abstract
To evaluate the shear bond strength and the fracture type of orthodontic tubes bonded directly with composite resin throughout the enamel surface. 30 bovine teeth were cut into 3 slices with 5 mm each and embedded in PVC pipes with acrylic resin exposing the buccal face. Subsequently, the teeth were submitted to conventional bonding techniques. Natural Ortho resin was applied for direct bonding of Edgewise Standard orthodontic tubes (Morelli®) and light-cured for 20s. A different viscosity resin was chosen and light-cured for 40s to reinforce the tube surface. The samples were divided into the following groups: Orthodontic tube with direct bonding without reinforcement

(CONTROL), Tube with Natural Ortho resin + Reinforcement (NO + NO), Tube with Natural Ortho resin + Reinforcement with Flow resin (NO + FL). These were submitted to shear bond strength; immediate and 1-year aging fracture analysis after simulated through thermocycling. In the shear bond strength test, the group of orthodontic tubes that were directly bonded with Natural Ortho resin and reinforced (NO + NO) showed greater strength results after 24 hours and 1 year with values of (p=0.0225) and (p=0.0273). It was statistically differentto the NO + FL and CONTROL reinforced groups. In the fracture analysis, the NO +NO group was classified immediately as composite cohesive, and mixed failure after aging by thermocycling. The addition of a composite resin layer on the surface of the directly bonded orthodontic tube improved bond strength. The reinforcement must be carried out in regular consistency and the use of Flow resin is not indicated.
Keywords: Orthodontic tube; Direct bonding; Resin reinforcement.

Resumo

Avaliar a resistência ao cisalhamento de tubos ortodônticos de forma direta com reforço de resina composta na superfície do esmalte. Foram utilizados 30 dentes bovinos, cortados em 3 partes de 5 mm de altura devido. Cada parte foi embutido em canosde PVC com resina acrílica de modo que a face vestibular ficasse exposta. Aplicou-se a resina fotopolimerizada Natural Ortho para a colagem direta do tubo ortodônticos Edgewise Standart (Morelli®), após a polimerização da resina por 20s, foi realizado o reforço em toda superfície do tubo com resina de diferente viscosidade fotopolimerizado a área por 40s. As amostras foram divididas nos seguintes grupos: Controle tubo ortodôntico com colagem direta sem reforço (CONTROLE), Tubo com resina Natural Ortho + Reforço (NO + NO), Tubo com resina Natural Ortho + Reforço com resina Flow (NO + FL) que foram destinados à resistência ao cisalhamento e análise de fratura imediata e após o envelhecimento de 1 ano simulado pela temorciclagem. No teste de cisalhamento, o grupo do tubo ortodôntico colados de forma direta com a resina Natural Ortho e reforçados (NO + NO) demonstrou melhores resultados de resistência após de 24 horas e 1 ano com valores de (p=0.0225) e p=0.0273). Ele foi estatisticamente superior aos grupos reforçados NO + FL e CONTROL Na análise de fratura o grupo NO +NO foi classificado no imediato como coesiva em compósito, e falha mista após envelhecimento por termociclagem. A adição de uma camada de resina composta na superfície no tubo ortodôntico colados de forma direta foi significante para melhorar a resistência de união. O reforço deve-se ser realizado na consistência regular e não é indicado o uso da resina Flow.
Palavras-chave: Tubo ortodôntico; Colagem direta; Reforço de resina.

Resumen

Evaluar la resistencia al corte y el tipo de fractura de los tubos de ortodoncia directamente con refuerzo de resina compuesta enla superficie del esmalte. Se utilizaron 30 dientes de bovino, cortados en 3 piezas de 5 mm de altura. Cada parte se incrustó en tubos de PVC con resina acrílica para que la cara bucal quedara al descubierto. Se aplicó resina fotopolimerizable Natural Ortho para la unión directa de tubos de ortodoncia Edgewise Standard (Morelli®) Después de la polimerización de la resina, toda la superficie del tubo se reforzó con resina de diferente viscosidad. Las muestras se dividieron en los siguientes grupos: Tubo de ortodoncia de control con unión directa sin refuerzo (CONTROL), Tubo con resina Natural Ortho + Refuerzo (NO + NO), Tubo con resina Natural Ortho + Refuerzo con resina Flow (NO + FL) que Se propusieron resistencia al cizallamiento (n=15) y análisis de fractura inmediata y después de 1 año de envejecimiento. En la prueba de cizallamiento, el grupo de tubo de ortodoncia unido directamente con resina Natural Ortho y reforzado (NO + NO) mostró mejores resultados de resistencia a las 24 horas y 1 año con valores de (p = 0.0625 yp = 0.0703). Fue estadísticamente superior a los grupos reforzados con NO + FLy CONTROL En el análisis de fracturas, el grupo NO + NO se clasificó inmediatamente como cohesivo en composite, y falla errónea después del envejecimiento por termociclado. La adición de una capa de resina compuesta en la superficie del tubo de ortodoncia directamente adherido fue importante para mejorar la resistencia de la unión. El refuerzo debe realizarse con consistencia regular y no está indicado el uso de resina Flow.
Palabras clave: Tubo de ortodoncia; Vinculación directa; Refuerzo de Resina.

1. Introduction

The success of a fixed orthodontic appliance depends on the bonding and correct positioning of its components, which results in an effective force transmission system. Thus providing an orderly and planned tooth movement (Baer et al., 1964; Oeiras et al., 2016). During the planning of fixed appliance and orthodontic mechanics, bands are basic elements, classically indicated for the molar region in which they are welded to orthodontic accessories (Limberger et al., 2011).

However, studies show that the use of cemented orthodontic bands on the tooth may cause damage to oral tissues as well as metabolic activity, changing the amount and pathogenicity of oral microbiota, which may cause the development of caries. It happens due to the balance change of demineralization and remineralization in this area. Moreover, the activation of inflammatory mechanisms culminates in hyperplasia in the surrounding gingival tissue (Baer et al., 1964; Sadowsky et al.,

1981; et al., 2011; et al., 2012). The study of direct bonding tubes that have advantages such as shorter operative time and lower periodontal risk is growing. (Nazir et al., 2011)

The use of orthodontic tubes for direct bonding for treatment with fixed appliances becomes possible due to the improvement of clinical techniques and evolution of dental materials. (Flores-mir et al., 2011). Thus, the bases were modified and changed from smooth structures to a mesh with grooves, which facilitated the overlapping of material, promoting adequate and higher bond strength to the tooth structure (Sharma, T et al., 2004;Perumal et al., 2004;Perumal et al., 2004). al., 2010). It craves to overcome clinical deficiencies, reducing the occurrences caused by orthodontic bands (Pinzan-Vercelino et al., 2011).

According to Tortamano et al (2016), the use of molar tubes glued directly to the tooth surface is increasing.

However, this technique still has flaws regarding its clinical survival, such as adequate resistance to withstand the forces promoted by orthodontic movement and areas with great masticatory effort such as lower posterior teeth (Millet et al., 2017). A new alternative to increase the strength of direct bonding is to add resin reinforcement to the surface of the orthodontic tube in order to increase the efficiency of traditional bonding for teeth subjected to greater masticatory impacts. This management aims to reduce the deficiency of the aforementioned technique, distributing the forces and facilitating cleaning (Dalanezi et al., 2011; Flores-Mir et al., 2011).

In addition, this method may be effective to increase the quality of bonding with greater contact between the tooth and tube. Although there is no sufficient report of resin reinforcement related to orthodontics tubes and its possible benefits for bonding to enamel. Therefore, the aim of this study is to evaluate the shear bond strength of tubes orthodontics directly bonded with resin reinforcement in different viscosities. The null hypothesis is that the reinforcement of composite resin to the orthodontic tube in its conventional or fluid form there will be no difference in mechanical shear strength.

2. Methodology

Preparation of specimens

Thirty healthy bovine teeth, obtained from a private establishment, were selected. Roots were sectioned at cementoenamel junction, cleaned and preserved in 0.1% thymol in a refrigerated environment. Subsequently, sectioned in a cutter (Isomet 1000, Buehler, Lake Bluff, IL) and divided into three slices, with a minimum height of 5mm measured with a digital caliper (Digimess, São Paulo, Brazil). Each tooth was embedded in rigid 4mm PVC pipes with acrylic resin to expose the buccal surface only. The use of these teeth in the research was adopted due to their similarity to human enamel. The acrylicresin was established with a combination of Self Curing Acrylic Pink Powder (JET, São Paulo, Brazil) and Self Curing AcrylicLiquid (JET, São Paulo, Brazil). The bovine tooth was inserted in the plastic stage.

Prophylaxis with pumice stone was performed for 30 seconds in all samples, changing the brush every five polishes. Then, the enamel was etched with 37% phosphoric acid Condac (FGM, Joinville, Brazil) for 30 seconds and washed with water for 60 seconds and air-dried from the triple syringe for 15 seconds. The fractures were classified as adhesive, cohesive in composite or dentin and mixed. Surface drying was performed with moisture-free air jets for 15 seconds. Subsequently, the Alpha Bond (DFL, Rio de Janeiro, Brazil) was applied vigorously for 20 seconds with a Carvibrush microbrush (FGM, Joinville, Brazil) according to the manufacturer's instructions, light cured for 20 seconds by LEDLUX II (Ortus, Goiânia, Brazil) with a luminous intensity of 1,400Mw/CM2 being controlled by a radiometer (Godard et al., 2017).

Natural Ortho light-cured resin was applied with tube clamps (Morelli®, Sorocaba, Brazil). The tubes used were: simple 018 Edgewise Standard (Morelli®, Sorocaba, Brazil), fixed on the buccal surface of the bovine teeth and pressed with aforce of 2 gf (gram force). The removal of excesses was carried out with an exploratory probe number 5 (Duflex, SS White, Brazil). After resin polymerization, the groups were reinforced with Natural Ortho Resin or Flow-Opallis Resin (FGM, Joinville, Brazil) on all tube surfaces and light cured for 40 seconds. All sets were stored in distilled water at 37 °C for 24 hours for immediate testing and thermocycling. In the group with resin flow, the reinforcement was applied through a syringe.

Thus, the samples were randomly divided into the following groups: Control with tube directly bonded without reinforcement (Control), Tube with Natural Ortho resin + Reinforcement (NO + NO), Tube with Natural Ortho resin + Reinforcement with Flow resin (NO+FL). After thermocycling: Control (Control 1y), Tube with Natural Ortho resin + Reinforcement (NO + NO 1y), Tube with Natural Ortho resin + Reinforcement with Resin Flow (NO + FL 1y).

Thermocycling

1000 cycles in distilled water was performed in a thermocycling machine (TC45, Peter Huber Kältemaschinenbau AG, Germany) at temperatures of 5°C (± 2°C) and 55°C (± 2°C). Each cycle was performed for 20 seconds, with an interval of5 to 10 seconds. The samples that were not submitted to the process were stored in refrigeration at 8°C.

Shear bond strength

The shear bond strength test was performed on EMIC Universal Testing machine (DL 2000, São José dos Pinhais, Brazil), with a load cell of 100 Kgf at a speed of 0.5 mm/min. The height, width and length measurements of each orthodontic tube were taken with the help of a caliper before the tests. The strength values were measured in Newtons (N) and MegaPascal (MPa). The mechanical shear bond strength test was performed following the cervical occluded direction, with the chisel positioned at the tooth-tube interface forming an angle of 90° (Figure 5).

Fracture Pattern Analysis

The failure mode of each fractured stick was analyzed using a stereomicroscope at 100x magnification (Olympus SZ 40-50, Tokyo, Japan). The fractures were classified as adhesive, cohesive in composite or dentin and mixed in composite or cohesive in dentin. Bond (when the failure occurred in the bonding system), cohesive in resin (when the fracture occurred inthe composite resin), cohesive in enamel/dentin (when the fracture occurred in the dental substrate) and mixed (when the analysis of both fragments showed the presence of bond).

Statistical analysis

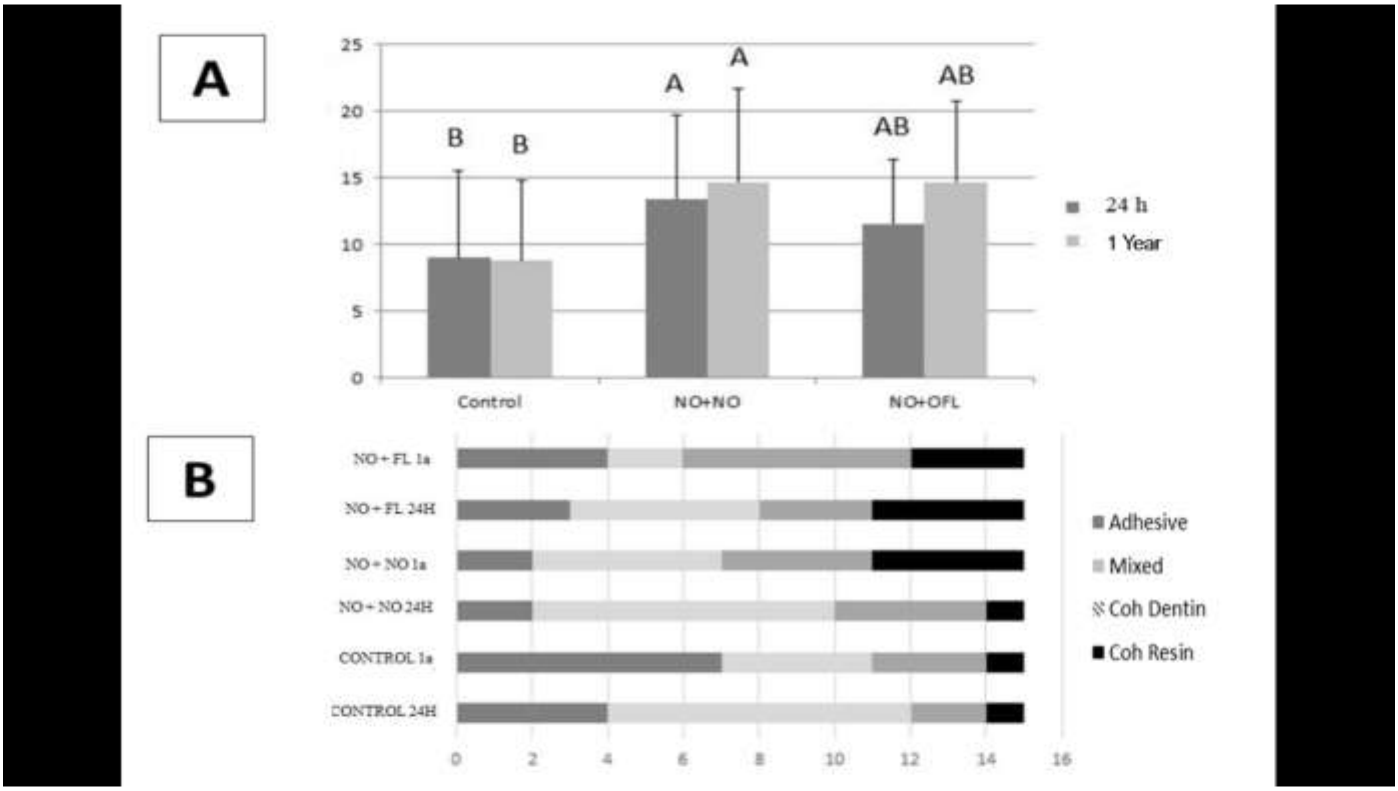
Data were organized in Microsoft Office Excel 2016 spreadsheets (Microsoft, Washington, USA) and distributed in Tables and graphs. Subsequently, the data were transferred to the statistical program Stat 32 with analysis of variance ANOVAand Tukey's complementary test with confidence interval at 99% and statistical significance established at $p<0.05$.

3. Results and Discussion

The shear bond strength test of orthodontic tubes bonded directly is shown in Figure 1. The NO + NO group showed satisfactory results of immediate and aging. It was statistically different compared to the Control group. The Control group showed lower bond strength compared to NO + FL, while this group obtained strength values from an intermediate bond with statistical difference. The NO + NO and NO + FL group were statistically differentcompared to the Control group.

The fracture pattern of the NO + NO and NO + FL groups were classified as cohesive composite within 24 hours. After aging by thermocycling, it was classified as mixed failure. The Control group had predominantly a high percentage of bond failure after 24h and mixed after aging time.

Figure 1.



Source: Authors.

4. Discussion

Since the additional layer of composite resin on the orthodontic tube surface may create an contact area between the tooth and the orthodontic tube, this study was based on comparing two composite resins in their fluid form (Opallis) and conventional orthodontic composite resin (Natural Ortho) and its bonding to enamel. The NO + NO group demonstrated greater shear bond strength test values. Thus, the null hypothesis was rejected, as the addition of composite resin conventional proved to be effective in resisting shear when compared to tubes without this method of reinforcement.

The area where the additional composite resin layer was applied may be easily sanitized, even if bonding materials present roughness in its structure (Figure 3). This fact is likely controlled in periodic appointments with a dentist. It's crucial not to hinder the passage of orthodontic wire for adequate tooth movement, as shown in Figure 4 (Wadia et al., 2019). In addition to being located far from the marginal gingiva, it does not damage periodontal tissues such as orthodontic bands (Millett et al., 2017). This method offers resistance to the forces of orthodontic and masticatory movement in view of the results obtained in this study, the orthodontic resins are shown in Figure 2 (Pg Murray et al., 2012). In the shear bond strength test, the NO + NO group obtained greater bond strength values with statistical difference compared to the Control group and the NO + FL group of (p=0.0225) and (p=0.0273). The reinforcement with fluid resin showed intermediate values of bond strength, increasing its result after thermocycling.

Figure 2.

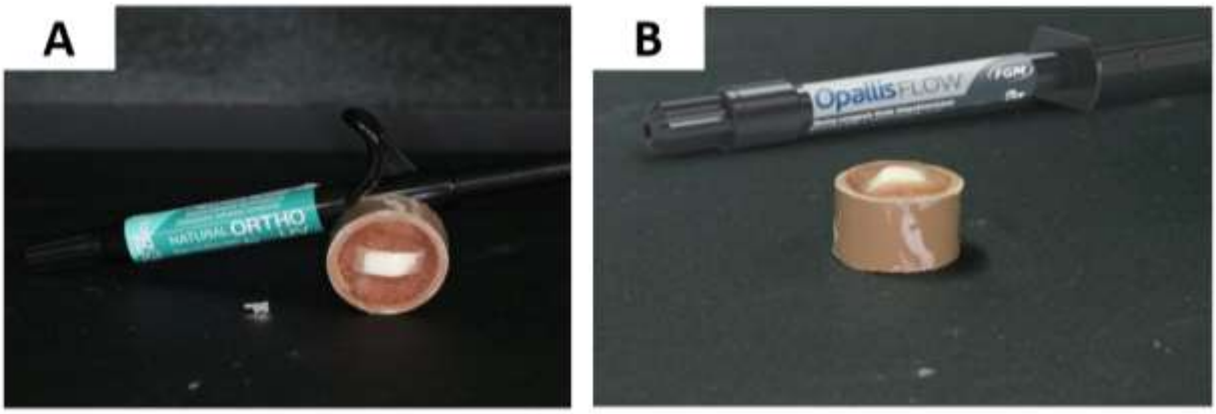


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Figure 3.

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Figure 4.

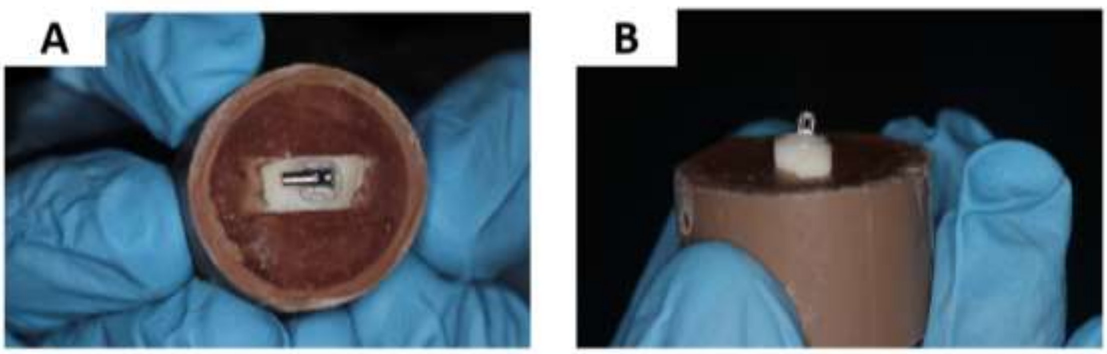

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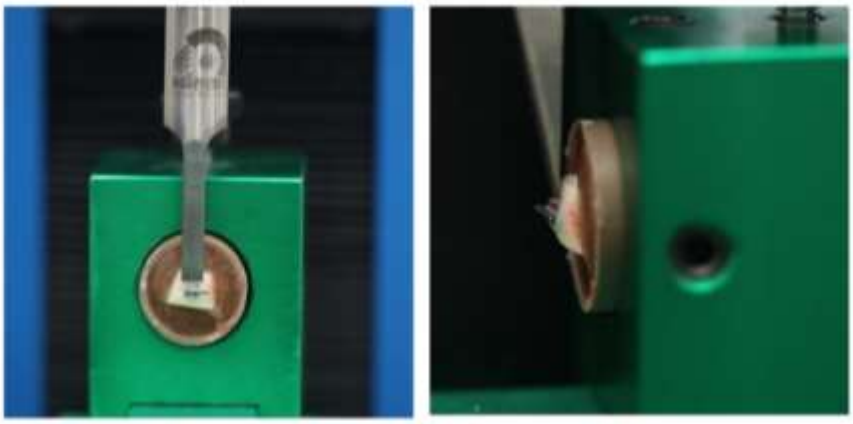
Figure 5.



Source: Authors.

Thus, these results may occur due to the different composition between composite resin in its conventional and fluid form. In its regular form, it has more viscous monomers of high molecular weight, such as BISGMA (bisphenol glycidyl methacrylate), with particle loading up to 85%. The fluid composite resin (flow) has fluid monomers with lower molecular weight and less amount of charge particles, reaching up to 70%. It directly influences the improvement of physical and mechanical properties which determine its performance and clinical indications. The filler particles reduce water absorption, reduce polymerization shrinkage, and improve stress absorption. Thus, the difference between the materials may be a fact that explains great results of the NO + NO group.

Corroborating this result, the analysis of fracture pattern of the NO + NO and NO + FL group was classified as cohesive in composite and mixed after 1 year, with less bonding failure when compared to the rest of the groups. The control group showed a higher percentage of bonding failure after aging, since this group was not reinforced with composite resin, clinically affecting the progress of treatment with fixed appliances. This failure would be a delaying factor in planning (Keim et al., 2010). However, for clinical use of this reinforcement method, it is recommended to quantify the bonding material to avoid the interference with the occlusal relation between the upper and lower molars.

To simulate oral aging, thermocycling was adopted for the study. It's an in vitro process that submits the restoration and the tooth to extreme temperatures compatible with those found in the oral environment (Rossomando et al., 1995). It simulates the aging of materials, which may influence the integrity of the restorative material and the cementing agent (Faria et al., 2004). After thermocycling, there were differences in thermal expansion between the bond, orthodontic attachment and enamel. The temperature change leads to weakness within the bond, affecting the bond and strength of the material. It simulates the clinical situation that these materials will be submitted to in the oral cavity (Liu et al., 2018). Thus, the control group had lower bond strength values when compared to the other two groups, being statistically different.

Pandis et al evaluated tubes bonded directly to molars (in vivo). It was found that the first failure was after 23 months (20 to 26 months). Therefore, in this study, the simulation time for 1 year of aging was adopted, approaching the analyzes already reported in the literature. Furthermore, thermocycling may cause microscopic expansion and chemical degradation of the materials used (Pandis et al., 2005; Purmal et al., 2010). It was noted that thermocycled compounds absorb a superior amount of water when compared to samples that were not submitted to this procedure (Morresi et al., 2014). Thus, it was considered as the reason for the control group not to obtain significant results of shear bond strength after aging. And after thermocycling, the NO + FL group managed to increase its bond value, being statistically lower than the NO + NO group.

Therefore, this alternative of reinforcement with composite resin in its conventional Natural Ortho form may be effective, as it has been shown to increase the quality of direct bonding of orthodontic tubes to enamel. It is necessary more studies focused on the area, once the technique performance depends on the proper selection of material

4. Conclusion

The reinforcement of Natural Ortho composite resin to direct bond tube is a promising method to increase bond and strength of these devices to enamel. Thus, future clinical studies focused on this subject are needed to assess its applicability and effectiveness.

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