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Patrícia Eliana Fontana

INFLUÊNCIA DE DIFERENTES MATERIAIS E DIFERENTES TÉCNICAS DE LIMPEZA DO ESPAÇO PARA O PINO EM DENTES RESTAURADOS COM PINOS ANATÔMICOS

Santa Maria, RS
2021

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Tese apresentada ao Curso de Doutorado do Programa de Pós-Graduação em Ciências Odontológicas, Área de Concentração em Odontologia, ênfase em Prótese Dentária, da Universidade Federal de Santa Maria (UFSM, RS), como requisito parcial para obtenção do grau de **Doutora em Ciências Odontológicas**.

Orientador: Prof. Dr. Osvaldo Bazzan Kaizer

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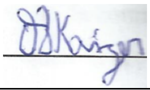

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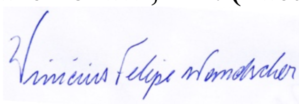

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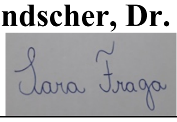

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RESUMO

INFLUÊNCIA DE DIFERENTES MATERIAIS E DIFERENTES TÉCNICAS DE LIMPEZA DO ESPAÇO PARA O PINO EM DENTES RESTAURADOS COM PINOS ANATÔMICOS

AUTORA: Patrícia Eliana Fontana
ORIENTADOR: Osvaldo Bazzan Kaizer

No presente trabalho serão apresentados dois artigos envolvendo a utilização de pinos anatômicos em dentes bovinos fragilizados tratados endodonticamente. A primeira delas, em formato de artigo, visou avaliar a resistência à fratura de dentes tratados endodonticamente restaurados com pinos de fibra de vidro reembasados com diferentes materiais. Para isso, 60 dentes incisivos bovinos foram distribuídos aleatoriamente em 6 grupos, de acordo com o tipo de material utilizado para reembasar o pino de fibra de vidro (One Bulk Fill, One Bulk Fill Flow, Z250 XT, Z350 XT, AllCem Core e Controle - não reembasado). Os espécimes foram submetidos à ciclagem mecânica (37°C, 45°, 130 N, 2,2 Hz e 5 x 10^5 pulsos). Os espécimes que sobreviveram à ciclagem foram submetidos ao teste de resistência à fratura a uma velocidade de 0,5 mm/min e a uma inclinação de 45° até a ocorrência da falha. As falhas foram classificadas como irreparáveis e reparáveis. Os dados foram analisados com ANOVA - dois fatores, teste Tukey e teste Chi-quadrado. O grupo One Bulk Fill Flow apresentou maior resistência à fratura, seguido respectivamente pelos grupos Z250 XT, One Bulk Fill, Z350 XT, Controle e Allcem Core, apesar de não haver diferença estatisticamente significante entre eles. Das fraturas, 51,72% foram desfavoráveis e 48,27% favoráveis. Os diferentes materiais utilizados para confeccionar pinos anatômicos não influenciaram na resistência à fratura dos dentes tratados endodonticamente ao canal radicular. Assim, para a confecção do pino anatômico podemos fazer uso de materiais que apresentem melhor versatilidade clínica. A segunda proposta, em formato de artigo, teve como objetivo avaliar a influência do tratamento do espaço para o pino e do tempo de espera após o tratamento endodôntico na resistência de união do pino anatômico à dentina do canal radicular. Oitenta dentes incisivos bovinos foram randomizados em oito grupos, de acordo com tratamento de limpeza para o espaço do pino (NaOCl 2,5% + EDTA 17%, Álcool 99%, água destilada, laser de diodo) e o tempo de espera após o tratamento endodôntico (24h e 6 meses). O teste de push-out foi realizado e as falhas foram analisadas por meio de estereomicroscópio. Para analisar a influência do tratamento do espaço para o pino e do tempo de espera foi utilizado ANOVA – dois fatores. O teste t foi realizado para comparar o tempo de espera com o mesmo tratamento para o espaço para o pino, e ANOVA – um fator para comparar tratamento do espaço do pino com o mesmo tempo de espera após o tratamento endodôntico. O tempo de espera para os grupos de 24 horas obteve os maiores valores de push-out, quando comparado com os grupos de 6 meses. O tratamento do espaço para o pino com álcool / 24 horas apresentou diferença estatística com o grupo laser de diodo / 24 horas. O tipo de falha mais comum foi entre o cimento e a dentina radicular. Os tratamentos do espaço para o pino e o tempo de espera após tratamento endodôntico tem influência na resistência de união do pino anatômico à dentina radicular.

Palavras-chave: Laser de diodo. Irrigação do espaço para o pino. Pino de Fibra. Pino Anatômico. Push-put. Resina Composta.

ABSTRACT

INFLUENCE OF DIFFERENT MATERIALS AND DIFFERENT POST-SPACE TREATMENT ON TEETH RESTORED WITH RELINED POST

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ADVISOR: Osvaldo Bazzan Kaizer

In the present work two articles will be presented involving the use of relined glass fiber post in endodontically treated bovine teeth weakened. The first proposal, in article format, aimes to evaluate the fracture resistance of endodontically treated teeth restored with glass fiber posts relined with different materials. For this, 60 bovine incisor teeth were randomly distributed in 6 groups, according to the material used to relined the glass fiber post (One Bulk Fill, One Bulk Fill Flow, Z250 XT, Z350 XT, AllCem Core and Control - not relined). The specimens were submitted to mechanical cycling (37°C, 45°, 130 N, 2.2 Hz and 5×10^5 pulses). The specimens who survived mechanical cycling were subjected to a fracture load test at a speed of 0.5 mm/min and a slope of 45° until failure occurred. The failures were classified as unfavorable and favorable. Data were analyzed with two-way ANOVA, Tukey's and chi-square test. The One Bulk Fill Flow group presented higher resistance to fracture, followed by Z250 XT, One Bulk Fill, Z350 XT, Control and Allcem Core groups, although there was no statistically significant difference between them. Of the fractures, 51.72% were unfavorable and 48.27% favorable. Different materials used to reline glass fiber posts don't influence in the fracture resistance of the endodontically treated teeth. Thus, the use of materials that present better versatility is the best clinical decision. The second proposal, in article format, aimed to the influence of the post-space treatments and post-endodontic waiting time on the bond strength of glass fiber post relined to root canal dentin. Eighty bovine incisor teeth were randomized into eight groups, according to post-space treatments (NaOCl 2.5% + EDTA 17%, Alcohol 99%, distilled water, diode laser) and post-endodontic waiting time (24h and 6 months). The push-out test was performed, and the failures were analyzed using a stereomicroscope. To analyze the influence of post-space treatments and post-endodontic waiting time, two-away ANOVA was used. The t-test was performed to compare the post-endodontic waiting time with the same treatment for the post space, and one-way ANOVA to compare treatment of the post space with the same post-endodontic waiting time. The post-endodontic waiting time for groups 24 hours obtained the highest values of push-out, when compared with groups 6 months. Post-space treatment with alcohol/24hours present statistical difference with the group diode laser/24 hours. The most common failure type was between cement and root dentin. The post-space treatments and post-endodontic waiting time have influence on bond strength of glass fiber post relined to root canal dentin.

Keywords: Composite Resin. Diode Laser. Fiber Post. Post space irrigation. Push-out. Relined post.

SUMÁRIO

1. INTRODUÇÃO

Para restaurar dentes tratados endodonticamente, os pinos de fibra de vidro são amplamente utilizados na prática clínica (SARKIS-ONOFRE et al., 2014), eles possuem propriedades estéticas favoráveis, biocompatibilidade, fácil remoção (BONFANTE et al., 2007), além de módulo de elasticidade semelhante à dentina radicular (BAKAUS et al., 2018; DE SOUZA et al., 2016; ROCHA et al., 2017; WEBBER et al., 2018). Isso proporciona uma distribuição de tensões mais uniforme ao longo do canal radicular, reduzindo o número de fraturas radiculares (BAKAUS et al., 2018; DE SOUZA et al., 2016; WEBBER et al., 2018).

Porém, em algumas situações o pino de fibra de vidro não se adapta de forma ideal ao diâmetro e/ou ao formato do canal radicular (ROCHA et al., 2017), como por exemplo em canais radiculares alargados e com anatomia oval (GOMES et al., 2016). Logo, a desadaptação do pino de fibra de vidro ocasiona uma espessura grande de cimento resinoso que pode gerar a formação de bolhas, elevada contração de polimerização e falhas na adesão (ROCHA et al., 2017).

Para melhorar a adaptação ao canal radicular, uma das opções possíveis de serem utilizadas são os pinos de fibra de vidro reembasados com resina composta, também conhecidos como pinos anatômicos (GRANDINI; SAPIO; SIMONETTI, 2003; WEBBER et al., 2018). Essa técnica proporciona uma redução na camada de cimento resinoso (CLAVIJO et al., 2009; ROCHA et al., 2017) e, consequentemente a redução da formação de bolhas (D'ARCANGELO et al., 2007), o que reduz a chance de fraturas (GOMES et al., 2016).

Também, o uso de pinos anatômicos mostrou ter melhores resultados de resistência de união em canais alargados em comparação com pinos não reembasados (MACEDO et al., 2010; FARIA-E-SILVA et al., 2009). Da mesma forma, ao avaliar a resistência à fratura de canais alargados, os pinos anatômicos apresentaram resultados similares aos pinos metálicos fundidos e resultado superior aos pinos não reembasados (CLAVIJO et al., 2009; GOMES et al., 2016).

Bakaus e colaboradores (2018), em seu estudo *in vitro* compararam a resistência de união entre pinos de fibra de vidro e diferentes materiais, como resina composta convencional e bulk fill, ionômero de vidro convencional e cimento autoadesivo para restaurar canais alargados. Os maiores valores de resistência de união foram observados no grupo com canal compatível com o pino, seguido do grupo que utilizou a resina composta bulk fill, resina composta convencional e por fim ionômero de vidro convencional. Com isso, foi demonstrado que as resinas bulk fill podem ser indicadas como alternativa as resinas convencionais para restaurar canais alargados, sendo a única a apresentar alta resistência de união no terço apical com relação aos outros materiais do estudo (BAKAUS et al., 2018). Porém, no nosso conhecimento, ainda não há um consenso a literatura sobre qual material geraria uma melhor resistência à fratura de dentes tratados endodonticamente restaurados com pinos anatômicos, necessitando de novos estudos com diferentes materiais.

Outro fator que pode alterar a resistência de união de pinos intrarradiculares à dentina radicular é o tratamento do espaço para o pino. O irrigante mais utilizado na prática clínica para fazer a limpeza do canal radicular é o hipoclorito de sódio – NaOCl, pois dissolve compostos orgânicos, apesar de não remover completamente a camada de smear layer (GARCIA et al., 2018). Para isso, o ácido etilenodiaminotetracético (EDTA) é amplamente utilizado (GARCIA et al., 2018). Alguns estudos sugerem que a associação desses dois agentes pode favorecer a limpeza do canal radicular (GARCIA et al., 2018; VIOLICH et al., 2010).

A aplicação do etanol 99% como método de limpeza do canal, também parece aumentar a adesão intrarradicular do pino de fibra de vidro, possivelmente porque a sua utilização ajuda a controlar a umidade intrarradicular (GOMES FRANÇA et al., 2015). Além disso, tem se utilizado diferentes lasers como o Nd:YAG, Er:YAG, Er,Cr:YSGG e de diodo, para a limpeza do canal radicular, apesar de não haver consenso de um protocolo de utilização (EKIM; ERDEMIR, 2015). Apesar disso, ainda há poucas evidências da influência dos lasers (EKIM; ERDEMIR, 2015), e de outras substâncias na adesão de pino anatômicos ao canal radicular (CECCHIN et al., 2011; CECCHIN et al., 2014a; CECCHIN et al., 2014 b; DE OLIVEIRA et al., 2018), bem como a influência do tempo de espera para cimentar o pino intrarradicular após o tratamento endodôntico, necessitando assim de maiores investigações (BOHRER et al., 2018).

Assim, considerando os contextos expostos, serão apresentadas duas propostas de pesquisa. A primeira proposta, em formato de artigo, intitulada "**Does glass fiber post relining material influence tooth fracture resistance?**", tem como objetivo avaliar a resistência à fratura de dentes tratados endodonticamente restaurados com pinos de fibra de vidro reembasados com diferentes materiais. A segunda proposta, também em formato de artigo, intitulada **"Can post-space treatment and post-endodontic waiting time influence on the bond strength of glass fiber post relined to root canal dentin?"**, objetiva avaliar a influência do tratamento do espaço para o pino e do tempo de espera após o tratamento endodôntico na resistência de união do pino anatômico à dentina do canal radicular.

2. ARTIGO 1 – DOES GLASS FIBER POST RELINING MATERIAL INFLUENCE TOOTH FRACTURE RESISTANCE?

Este artigo está submetido ao periódico *The International Journal of Prosthodontics*, ISSN: 0893-2174, Fator de impacto = 2.13; Qualis A2. As normas para publicação estão descritas no Anexo A.

DOES GLASS FIBER POST RELINING MATERIAL INFLUENCE TOOTH FRACTURE RESISTANCE?

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DOES GLASS FIBER POST RELINING MATERIAL INFLUENCE TOOTH FRACTURE RESISTANCE?

ABSTRACT

Objective: To evaluate the fracture resistance of endodontically treated teeth restored with glass fiber posts relined with different materials. **Methods:** Sixty (60) bovine incisor were endodontically treated, with the post-space prepared and enlarged (except for the control group). They were subsequently randomized into six groups based on the material used to reline the glass fiber post (One Bulk Fill, One Bulk Fill Flow, Z250 XT, Z350 XT, Allcem Core) and the Control group (no relining). The glass fiber posts, relined posts and metal crowns were cemented using a self-adhesive resin cement (RelyX U200). The samples were subjected to mechanical cycling (at 37°C, 45°, 130 N, 2.2 Hz, and 5×10^5 cycles). Next, the specimens which survived the mechanical cycling were subjected to a fracture load test at a speed of 0.5 mm/min and on a 45° slope until failure occurred. The failures were classified as unfavorable and favorable. The data were analyzed using one-way analysis of variance. The failure pattern was analyzed using the chi-squared test. **Results:** The fracture resistance values were similar between the groups (One Bulk Fill Flow: 552.67 N, Z250 XT: 543.06 N, One Bulk Fill: 436.10, Z350 XT: 530.84 N, Control: 497 N, Allcem Core: 439.27 N). Of the fractures, 51.72% were unfavorable, while 48.27% were favorable. **Significance:** Different materials used to reline glass fiber posts did not influence the fracture resistance of the endodontically treated teeth. Thus, the clinician can use the material of their preference in preparing the relined post.

Keywords: Composite Resins; Teeth, Endodontically Treatment; Post and Core technique; Wide Canals.

Introduction

Glass fiber posts are widely used in clinical practice to restore endodontically treated teeth.[1] They have a favorable aesthetic property, as well as a similar modulus of elasticity to dentin.[2-4] This provides more uniform distribution of tension along the root canal, reducing the number of root fractures.[2,3]

However, the glass fiber posts do not ideally adapt to the diameter and/or shape of the root canal in some situations[4]. Maladaptation of the glass fiber post causes a large thickness of resin cement which can generate bubbles, cracks, high polymerization shrinkage and adhesion failures.[4]

Thus, several materials have been used to restore flared roots in order to improve the adaptation to the root canal, among them accessory fiber posts, fiber strips, and composite resins.[5,6] In addition, relining the glass fiber post with composite resin is one of techniques, also known as anatomical posts.[7] This technique provides a reduction in the resin cement layer[4,8] and consequently reduced bubble formation,[9] which reduces the risk of fractures[12]. Relined posts have also presented similar results to cast post and cores and superior results to non-relined posts when evaluating the fracture resistance of flared roots.[8,10]

Different types of resin composites have been evaluated in the literature for composing relined posts.[2,7,8] Bulk fill resin has recently been introduced in the market to facilitate the clinical procedure. This composite resin can be used in increments up to 4 mm thick due to their translucency,[11,12] as well as having adequate microhardness, low shrinkage, high curing depth and low degree of infiltration.[2] Bakaus, et al.[2] (2018) demonstrated that bulk fill resins can be indicated as an alternative to conventional resins to restore flared roots, being the only one to present high bond strength in the apical third compared to other study materials.[2]

Furthermore, resin core cement was launched on the market with the purpose of being used for both the adhesive cementation of the intrarradicular post, as well as for constructing the filling core. This cement has the advantage of reducing clinical time and optimizing care. However, there is still no consensus in the literature on which material would generate better resistance to fracture of endodontically treated teeth restored with relined posts, thus requiring new studies with different materials.

In view of the appearance of these new materials and the scarcity of laboratory studies to investigate their use in relined posts, the objective of this study was evaluate the fracture resistance of endodontically treated teeth restored with glass fiber posts relined with different materials. The null hypothesis is that the different materials for relining the glass fiber post do not influence the fracture resistance of endodontically treated teeth.

Methods and Materials

The number of teeth to be used in the present research was determined by performing a sample calculation with the OpenEpi 3.01 program[13] with the data obtained in the pilot study, the power of the study was defined as 80%, with a level of significance of 0.05.

Sixty (60) bovine incisor teeth were selected and the coronal portion of each tooth was sectioned at a distance of 16 mm from the root apex to standardize the root length. The selected teeth were subsequently randomized through a website (random.org) into six groups (n = 10 in each group) based on the material used in the relined glass fiber post (One Bulk Fill, One Bulk Fill Flow, Z250 XT, Z350 XT, Allcem Core, and Control group - no relining). The mesio-distal and vestibular-lingual dimensions of the teeth were measured with digital calipers (Starrett 727, Starrett, Itu, São Paulo, Brazil) in order to avoid differences in tooth size among the groups, and the measurements were then tabulated. The data were verified to be normally distributed. A one-way ANOVA was subsequently performed to verify if there were significant differences in the measured dimensions between the groups. No statistically significant difference (α=0.05) in the teeth dimensions could be detected. All procedures were performed by two trained researchers.

The periodontal ligament and the biological space were simulated.[14,15] The root was then prepared for endodontic treatment using second and third series endodontic files (Dentsply-Maillefer, Ballaigues, Switzerland) and nos. 3, 4, and 5 Gates-Glidden burs (Dentsply-Maillefer, Ballaigues, Switzerland), using the step back technique. The specimens were filled with AH plus sealer (Dentsply-Maillefer, Ballaigues, Switzerland) and the root canals were obturated with gutta-percha cones (Dentsply-Maillefer, Ballaigues, Switzerland). The compaction technique used was cold lateral condensation with a force of 2000 *g* standardized through a digital scale.[16] The specimens were stored in deionized water in 100% relative humidity at 37°C for 24 hours.

Root canal filling was partially removed with a hot instrument and 12 mm of the gutta-percha was removed with the standardized drills of the Whitepost DC No. 2 fiberglass post system (FGM, Joinville, Santa Catarina, Brazil). Next, the root canals were weakened with a # 4137 high-speed diamond bur (KG Sorensen, Cotia, São Paulo, Brazil) which was inserted 10 mm into the canal under water irrigation. Only the control group was not weakened.

The glass fiber post (White Post DC # 2, FGM, Joinville, Santa Catarina, Brazil) was cleaned with 70% alcohol and silane coupling agent was applied (FGM, Joinville, Santa Catarina, Brazil) to prepare the relined posts, according to the manufacturer's instructions.

Next, a layer of water-soluble lubricating gel (KY, Johnson & Johnson, São José dos Campos, SP, Brazil) was applied to the root canal using a microbrush (Cavibrush Extrafino, FGM, Joinville, Santa Catarina, Brazil). Thus, the material corresponding to each group was condensed inside the root canal, the glass fiber post was positioned, and the composite resin was light cured (1200 mW/cm^2, Radiical, SDI, Victoria, Australia) for 10 seconds on the occlusal surface. Then, the relined post was removed, light cured for another 40 seconds and reinserted to verify its adaptation.

When Allcem Core resin cement (FGM, Joinville, Santa Catarina, Brazil) was used for the relined post, the cement was applied to the root canal according to the manufacturer's recommendations. The glass fiber post was not relined for the control group.

The post space was washed with physiological saline and dried with paper cones in order to cement the glass fiber posts of all groups. Silane coupling agent (FGM, Joinville, Santa Catarina, Brazil) was applied to the relined glass fiber post according to the manufacturer’s instructions.

The cementation of the relined posts and the group control was performed with resin cement (RelyX U200, 3M-ESPE, Seefeld, Germany), which was manipulated according to the manufacturer’s instructions, except for the Allcem Core group. The specimens were stored at 37°C for 24 hours.

The cores were made using the corresponding material used for relined post of each group and a standardized acetic matrix. Thus, the matrices were filled with composite resin or resin cement and adapted in the coronary portion of the post. Z250 XT (3M-ESPE, Seefeld, Germany) composite resin was used to make the core for the control group. The coronal portions were prepared using 37% phosphoric acid (Condac 37, FGM, Joinville, Santa Catarina, Brazil), and the adhesive Single Bond 2 (3M/ESPE, Seefeld, Germany) was applied according to the manufacturer’s guidelines, except for the Allcem Core group.

The matrices were removed after the composite resin was photo-activated for 5 s, and then photo-activated for another 10 seconds on each face of the tooth. Full-metal crowns (Ni-Cr alloy; Wirona light, Bego, Goldschlagerei, Germany) were made with standardized shape and dimensions for all groups, according to the anatomy of a maxillary canine.

The adaptation of the full-metal crowns was evaluated, then air-abraded with aluminum oxide (110 µm, pressure: 2.8 bars) at a distance of 10 mm for 15 seconds. The full-metal crowns were cleaned with absolute alcohol prior to being cemented. Next, the full-metal crowns were cemented with a resin cement (RelyX U200, 3M/ESPE, Seefeld, Germany), following the manufacturer’s guidelines. Then, a 5-kg load was applied on each metal crown by means of a static press during cementation. Excess cement was removed after three minutes, and photo-activation was performed (1200 mW/cm^2, Radiical, SDI) on each side of the tooth for 10 seconds. The samples were stored for 24 hours before testing.

Mechanical cycling

The specimens were subjected to mechanical cycling (Erios ER 3000, São Paulo, Brazil) for aging with the following protocol: 2.2 Hz frequency, 5 x10^5 cycles from 0 N to 130 N, immersion in water at ± 37°C temperature, piston at a 45° angle with respect to the long axis of the root and at 2 mm distance from the lingual incisal edge. Approximately 6 months of clinical service was simulated in this study, taking into account the study by Wiskott, et al.[17] (1995) which declared that 1 million cycles correspond to one year of service.[17]

Fracture load test

Next, the specimens which did not present cracks were subjected to the fracture load test in a universal testing machine (DL 2000, Emic, São José dos Pinhais, Brazil). They were analyzed for the presence of fractures, and those which did not present cracks were subjected to the fracture load test using the following protocol: each sample was positioned on a fixed metal device and aligned at a 45° angle under 0.5 mm/min until failure occurred; the cylindrical metallic tip (diameter 0.8 mm) was attached to the load cell (1000 kN) applied to the lingual load (2 mm from the lingual incisal edge). The failure threshold was defined as the loading point in which the force reached a maximum value presenting root fracture, post-curvature and core fracture and post-displacement.

Failure analysis

The roots were superficially stained with hydrographic pens (Blue overhead marker, Faber-Castell, São Carlos, Brazil) after the fracture load test for the failure analysis. The specimens were visualized with a stereomicroscope at a 10x magnification (Stereomicroscope Discovery V20; Carl Zeiss, Germany) after removing the excess ink with cotton and 70% alcohol. The failures were classified as favorable (i.e. above the 3 mm limit of the acrylic resin – up to the limit of the simulated cement-enamel junction (CEJ)) and unfavorable (i.e. below the aforementioned limit – below the CEJ).[14]

Data analysis

The fracture load data were analyzed using the Shapiro Wilk test for their distribution, and their homogeneity was analyzed using the Levene test. It was found to have homogeneous and normal distribution ($p>0.05$). Next, the fracture load data were submitted to one-way ANOVA ($\alpha>0.50$). In addition, the chi-squared test was used to analyze the association between the different failure patterns and the different groups.

Results

Mechanical cycling

In total, 96.66% of specimens survived the mechanical cycling. Two favorable failures occurred in the Z250 XT group, one presenting a crack until the mesial region and other in the distal region.

Fracture load

The ANOVA test showed no significant difference between the groups (Table 1). The One Bulk Fill Flow group showed the highest fracture load value, and the Control group the lowest fracture load value.

Failure analysis

A total of 48.27% of the fractures were favorable and 51.72% were unfavorable (Table 2). The Control group showed the most unfavorable failures (90%). Displacement of the lingual portion of the crown occurred in 55% of the specimens, and the surface which presented the most cracks in the radicular thirds was the distal surfaces, followed by the mesial. Regarding to the failure pattern, there was no statistically significant difference between the groups (Table 3). The Control group showed the highest number of unfavorable failures.

Discussion

The present study showed that the different materials used to reline glass fiber post do not influence the fracture resistance of endodontically treated teeth. Thus, the null hypothesis was accepted.

Mechanical cycling of the specimens was performed to simulate real-life aging. We applied 500,000 cycles in this study, which is equivalent to approximately half a year of clinical service.[17] We found that 96.66% of specimens survived the mechanical cycling. In the failure analysis which occurred after mechanical cycling, two favorable failures were found in the Z250 XT group. The other groups did not show any failures. These results are in line with other similar studies.[6,14]

The One Bulk Fill Flow group presented greater numerical fracture resistance, followed by the Z250 XT, One Bulk Fill, Z350 XT, Control and Allcem Core groups (Table 1). The similarity in the composition (Table 4) and mechanical property of the materials used for manufacturing relined glass fiber post may explain the similarity in the fracture resistance between the materials.

Pereira, et al.[18] (2018) evaluated the degree of conversion and the polymerization-shrinkage stress of three dental composites (microhybrid, One Bulk Fill flowable and nanohybrid composite).[18] Their study showed that the One Bulk Fill composite presented a better degree of conversion and similar polymerization shrinkage stress to the conventional composite.[18] They also suggested that One Bulk Fill may perform as well as conventional nanohybrid and microhybrid composites.[18] In addition, in studying the polymerization shrinkage, Rizzante, et al.[19] (2019) found that One Bulk Fill resin composite presented similar to lower volumetric shrinkage when compared with conventional resin composites.[19] These studies also showed the similarity of the mechanical properties between the different composite resins.

Therefore, based on the results of this study which showed similarity between the materials used, the dentist can use a resin which is easier to handle or the resin which is available in the clinic for manufacturing the relined glass fiber post. In this context, the Z250 XT resin was the easiest to manipulate and insert into the root canal among the materials used in this study for relined glass fiber post, thus facilitating the clinical procedure. The ease of handling of the Z250 XT composite resin may be due to the higher percentage of particles (60%) (Table 4) present in its composition when compared to the other composite resins used in this study.

In addition, the mechanical behavior of the composite resins in the root canal may be different than when used to restore the coronary portion. This may occur because the cavity configuration factor (ratio of bounded to unbounded surface areas of cavities, C-factor) varies in each of these scenarios. The C-factor is critical and may compromise post adhesion when it is greater than 5.[20] The C-factor can vary from 20 to 100 in the root canal, depending on the root diameter, and is always considered critical.[20]

The material composition may influence the amount of contraction stress after the polymerization,[21] and consequently the C-factor. Composites which contain higher levels of inorganic filler particles are more likely to produce high levels of polymerization stress.[22] The polymerization contraction in the root canal may exceed the cement/dentin adhesion force, thereby causing post debonding.[20] Thus, the low degree of polymerization conversion of the resinous materials in the root canal does not necessarily reduce the post retention, since a lower polymerization contraction can generate less stress, favoring root adhesion.[20,21] In this context, the composite resin used to relined the glass fiber post in our study was light cured in and out of the root canal, thus not influencing the amount of resin loading, which could justify the similarity of the results between the groups.

The groups presented similar results regarding the failure pattern, showing no statistically significant difference between them (Table 3). In the One Bulk Fill, One Bulk Fill Flow and AllCem Core groups, 40% of the failures were favorable and 60% were unfavorable. The Z250 XT group presented 37.5% of favorable failures and 62.5% of unfavorable failures. The Z350 XT group had 20% favorable failures and 80% unfavorable failures. Already, the control group presented the least favorable failures (10%). Due to the similarity of materials and the way their photopolymerization was carried out, the difference in their compositions is minimized, and therefore does not seem to affect the fracture resistance of the teeth.

Further regarding the failure pattern after fracture load, it was observed that the roots presented more mesial and distal cracks, regardless of the type of material used to reline the glass fiber post. These rates are similar to other studies which analyzed the failure pattern of endodontically treated teeth restored with intrarradicular posts,[6,14] and may be due to the loading mode of specimens being 45°.[14]

It has been shown that the lingual surface suffers tensile forces and the buccal surface is compressed when subjecting the teeth to oblique loads.[6,14,22,23] The tensions in the center of the restorative set are minimal, and are maximum in the buccal and lingual portions.[14] Wandscher, et al.[6] (2014) stated that a sequence of events such as shear stresses at the post-dentin adhesive interface lead to the final fracture and may cause decementation of the assembly-crown displacement.[6] As a result, post decementation occurs and becomes loose in the canal, eventually rupturing the buccal wall due to greater compressive stress, which may lead to the most prevalent final failure (mesial and distal) which occurred in this study and others.[6,14]

The limitation of this study was the sample loading by mechanical cycling. Although mechanical cycling is an in vitro methodology which is closer to real aging conditions, it is difficult to reproduce factors such as load direction, pH alterations, humidity and temperature. Thus, new in vivo studies which simulate factors that cannot be represented in the laboratory, as well as the use of different materials, are necessary to confirm the results of this research.

Conclusion

- Different materials used to reline glass fiber posts did not influence the fracture resistance of the endodontically treated teeth. Thus, a clinician may use materials and the method of their preference for producing relined glass fiber posts.

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Tables

Table 1 - Mean (± standard deviation) of the fracture load (N) test results.

GROUPS	MEAN (SD)
ONE BULK FILL	436.10 (114.55) [A]
ONE BULK FILL FLOW	552.67 (125.72) [A]
Z250 XT	543.06 (178.66) [A]
Z350 XT	530.84 (90.97) [A]
ALLCEM CORE	439.27 (94.21) [A]
CONTROL	497 (97.19) [A]

*Upper case letters compare groups with different materials.

Table 2 - Qualitative evaluation of failures after mechanical cycling and fracture load test.

			STUDY GROUPS (n / %)						
			ONE BULK FILL	**ONE BULK FILL FLOW**	**Z250 XT**	**Z350 XT**	**ALLCEM CORE**	**CONTROL**	**TOTAL**
FAILURES DURING MECHANICAL CYCLING	**Failure Pattern**	**Favorable**	-	-	2	-	-	-	2
		Unfavorable	-	-	-	-	-	-	-
	Failure Place	**Crown Displacement (lingual)**	-	-	-	-	-	-	-
		Mesial crack	-	-	1	-	-	-	-
		Buccal crack	-	-	-	-	-	-	
		Distal crack	-	-	1	-	-	-	-
		Lingual crack	-	-	-	-	-	-	-
		Fracture in the post	-	-	-	-	-	-	-
		Crown, core, post pull out	-	-	-	-	-	-	-
FAILURES AFTER FRACTURE LOAD	**Failure Pattern**	**Favorable**	4(40%)	4(40%)	3(37.5%)	2(20%)	4(40%)	1(10%)	28(48.27%)
		Unfavorable	6(60%)	6(60%)	5(62.5%)	8(80%)	6(60%)	9(90%)	30(51.72%)
	Failure Place	**Crown Displacement (lingual)**	5	5	5	4	7	7	33
		Mesial crack	9	10	8	8	10	7	52
		Buccal crack	5	5	3	7	5	4	29
		Distal crack	9	10	6	10	10	9	54
		Lingual crack	-	-	-	-	-	-	-
		Fracture in the post	-	-	-	-	-	-	-
		Crown, core, post pull out	5	4	3	6	3	3	24
	Failure mode	**Mesiodistal**	9	10	6	7	10	7	49
		Buccolingual	1	-	4	3	-	3	11

Table 3 – Association between groups and failure pattern, according to the Chi-squared test.

FAILURE PATTERN	MATERIALS					
	One Bulk Fill	One Bulk Fill Flow	Z250 XT	Z350 XT	AllCem Core	Control
	A	A	A	A	A	A
Favorable	40%	40%	37.5%	20%	40%	10%
Unfavorable	60%	60%	62.5%	80%	60%	90%

*Upper case letters in the column compare groups with different materials.

Table 4 - Materials used to reline glass fiber post and their composition.

Material (manufacturer)	**Composition**	**Inorganic load**	**Percentage of particles (volume)**
One Bulk Fill (3M; St Paul, MN, USA)	Bis-GMA, Bis-EMA, UDMA, TEGDMA, AFM, AUDMA, UDMA and DDDMA	Zirconia/silica, ytterbium trifluoride	58.5%
Filtek Bulk Fill Flow (3M; St Paul, MN, USA)	UDMA Bis-EMA Bis-GMA	Zirconia/Silica	42.5%
Filtek Z250 XT (3M; St Paul, MN, USA)	UDMA Bis-EMA BisGMA TEGDMA	Zirconia/Silica	60%
Filtek Z350 XT (3M; St Paul, MN, USA)	BisGMA UDMA TEGDMA BIS-EMA	Zirconia/Silica	55.5%
AllCem Core (FGM; Joinvile, Brazil)	Base paste: TEGDMA, Bis-EMA and Bis_GMA, camphorquinone, co-initiators, barium-alumino-silicate glass microparticles, silicon dioxide nanoparticles, inorganic pigments and preservatives. Catalytic paste: monomers and methacrylates, dibenzoyl peroxide, stabilizers and barium-alumino-silicate glass microparticles.	Barium-alumino-silicate/Silicon dioxide	60% (weight)

AFM: monomer for dynamic relief of contraction stresses from polymerization; AUDMA: high molecular weight aromatic urethane dimethacrylate; Bis-GMA: bisphenol A glycidyl methacrylate; Bis-EMA: ethoxylated bisphenol A dimethacrylate; DDMA: 1,12-dodecanodiol dimetacrilato; HEMA: 2-hydroxyethyl methacrylate; TEG-DMA: triethyleneglycol dimethacrylate; UDMA: urethane dimethacrylate.

3. ARTIGO 2 - CAN POST-SPACE TREATMENT AND POST-ENDODONTIC WAITING TIME INFLUENCE ON THE BOND STRENGTH OF GLASS FIBER POST RELINED TO ROOT CANAL DENTIN?

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CAN POST-SPACE TREATMENT AND **POST-ENDODONTIC WAITING TIME INFLUENCE ON THE BOND STRENGTH OF GLASS FIBER POST RELINED TO ROOT CANAL DENTIN?**

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CAN POST-SPACE TREATMENT AND POST-ENDODONTIC WAITING TIME INFLUENCE ON THE BOND STRENGTH OF GLASS FIBER POST RELINED TO ROOT CANAL DENTIN?

ABSTRACT

Introduction: This study aimed evaluate the influence of the post-space treatments and post-endodontic waiting time on the bond strength of glass fiber post relined to root canal dentin. **Methods:** Eighty bovine incisor teeth were endodontically treated. The teeth were randomized into 8 groups, according to the post-space treatments (NaOCl 2.5% + EDTA 17%, Alcohol 99%, distilled water, diode laser) and the post-endodontic waiting time (24h and 6 months). The glass fiber post relined was made and the post cemented using resin cement. The push-out test was performed, and the failures analyzed using a stereomicroscope. The push-out data were analyzed for normality and homogeneity, two-way ANOVA was performed to analyze the influence of the post-space treatment and the time storage on bond strength of glass fiber post relined to root canal dentin. T-test was performed to compare post-endodontic waiting time with the same post-endodontic treatment, and one-way ANOVA to compare post space treatment teeth with the same post-endodontic waiting time. **Results:** The post-endodontic waiting time for groups 24 hours obtained the highest values of push-out, when compared with groups 6 months. Post-space treatment with alcohol/24hours present statistical difference with the group diode laser/24 hours. The most common failure type was between cement and root dentin. **Conclusions:** The post-space treatments and post-endodontic waiting time have influence on bond strength of glass fiber post relined to root canal dentin. The best bond strength results were when using alcohol / 24 hours for post-space treatment.

Keys-words: diode laser, fiber post, post space irrigation, push-out, relined post.

INTRODUCTION

Glass fiber posts are commonly used to restore endodontically treated teeth with extensive coronary destruction (1,2). In oval or weakened root canals, it has been proposed to use glass fiber post relined with composite resin, in order to improve their adaptation to the root canal (3). Thus, by being more adjusted to the root canal, the glass fiber post relined with resin composite promote a smaller layer of cement, which may reduce the formation of bubbles and adhesive failures (3).

One of the clinical failures that can occur in endodontically treated teeth restored with fiber posts is the debonding of the post (4). Innumerable elements can be influenced the adhesion oh the fiber post to root canal dentin, for example: the endodontic treatment, materials used for cementation, post-endodontic waiting time (5), and the treatment for post-space (2).

The preparation for the post-space generates smear layer that is rich in sealer and gutta-percha remnants (6,7), mainly when there is no irrigation, compromising the bond strength of fiber post to root canal dentin (2). Numerous treatments have already been proposed in order to promote the cleaning of the root canal after the post-space preparation (8-10), among them is sodium hypochlorite, and ethylene diamine tetra-acetic acid (NaOCl + EDTA) (8), erbium-doped yttrium aluminum garnet laser (Er: YAG laser) (11), neodymium-doped yttrium aluminum garnet laser (Nd: YAG laser) (12), diode laser (8), and ethanol (13). Nevertheless, there are still few studies evaluating the influence of the post-space treatments in teeth restored with glass fiber post relined with resin composite (4,13,14).

Another factor that can influence the bond strength of the glass fiber post to root canal dentin is the post-endodontic waiting time. The longer the cement remains in the root canal dentin, the more it penetrates the dentinal tubules, which can influence the adhesion (5).

Thus, this study aimed evaluate the influence of the post-space treatments and post-endodontic waiting time on the bond strength of glass fiber post relined to root canal dentin. The null hypothesis of our study was that there is no difference in post-space treatments and post-endodontic waiting time on the bond strength of glass fiber post relined to root canal dentin.

MATERIALS AND METHODS

Specimen selection

The sample calculation was performed using the OpenEpi 3.1 program (15), following the parameters described in the study by Cecchin et al (2011) (4). The power of the study was 80% and the level of significance of 0.05. As a result, 8 specimens per group were needed, but due to the variability of bovine teeth, 10 teeth per group were used. All procedures were performed by two trained operators.

The coronary portions of the eighty bovine incisors were sectioned to obtain roots with a length of 16 mm. With the anatomical size of an endodontic file type K # 80 (Dentsply-Maillefer, Ballaigues, Switzerland) the roots were selected, thus reducing the size variation between the root canals.

Also, with the same objective, the canals were measured with a digital caliper (Starrett 727, Starrett, Itu, São Paulo, Brazil), in the mesio-distal and vestibulo-lingual distances, the measures were tabulated, and the data were checked for its normality. The one-way ANOVA revealed that there was no statistical difference between the dimensions of the groups.

Then, for the bovine roots to be embedded, self-curing acrylic resin (VIPI; Pirassununga, SP, Brazil) was used. The samples were randomized by the website random.org, in groups according to post-space treatments and post-endodontic waiting time (Table 1).

Endodontic treatment

Endodontic treatment was performed with the stepback technique, using second and third series endodontic files (Dentsply-Maillefer, Ballaigues, Switzerland), in addition to no. 3, 4, 5 Gates-Glidden drills (Ângelus, Londrina, Paraná, Brazil). For filling, Bio-C Sealer bioceramic cement (Ângelus, Londrina, Paraná, Brazil) and gutta-percha cones (Dentsply-Maillefer, Ballaigues, Switzerland) were used, according to the manufacturer's guidelines. The technique used for filling the canal was cold lateral condensation with standardized force in 2000g, using a digital scale (5). Specimens were stored in deionized water at 100% relative humidity at 37 ° C for 24 hours or 6 months.

Preparation of glass fiber post relined and post-space treatments

After storing the specimens, according to the group, the root canals were prepared with heated instrument and drill of the used fiber post system (Exacto, n3, Ângelus, Londrina, Paraná, Brazil). For the weakening of the root canals, diamond burs #4137 (KG Sorensen Indústria e Comércio Ltda.) was used in high rotation (Extra Torque 605C; Kavo do Brasil Ind. Com. Ltda, Joinville, SC, Brazil) inserted 10 mm in the root canal under constant irrigation.

To make the glass fiber post relined, a layer of water-soluble lubricating gel (KY, Johnson & Johnson, São José dos Campos, SP, Brazil) was applied to the root canal with the aid of a microbrush (Cavibrush, FGM, Joinville, Brazil) a in order to avoid joining the material that will shape the root canal.

The glass fiber posts (Exacto, n3, Ângelus, Londrina, Paraná, Brazil) before molding the root canal, were cleaned with 70 alcohol and silane applied to its surface (Silano, Ângelus, Londrina, Paraná, Brazil) according to the manufacturer's recommendations. The composite resin (Filtek Z250 XT, 3M / ESPE) was condensed internally to the root canal, the glass fiber post was positioned and the set photo-activated (1200 mW / cm2, Radiical, SDI, Victoria, Australia) for 5 seconds on its occlusal surface. After photo-activation, the set was removed, photo-activated for another 40 seconds and reinserted to verify its adaptation. Then, the root canals were washed with distilled water with 5 ml of solution, in order to remove the lubricating gel.

The post-space was cleaned according to the group to which they belonged. The control group, the root canals were washed with distilled water for 1 min, with 5 ml of solution. The NaOCl 2.5% +

EDTA 17% group, the root canals received 2.5% NaOCl for 1min, with 5ml of solution, and after 5ml EDTA 17% for 1min (16). The 99% Alcohol group (Novaderme, Santa Maria, Rio Grande do Sul, Brazil), the root canals also received 5ml of solution for 1 minute (17).

The diode laser group used the diode laser (Thera Lase Surgery, DMC, São Carlos, São Paulo, Brazil) with a wavelength of 980nm, at a power of 1.5W and a frequency of 100Hz. For the application the root canal was kept dry. The laser was applied with helical movements for 8 seconds on the dentin surface. Then, 2mm of the laser tip was removed and a new application was performed (18).

All groups were cleaned with saline solution for 1 min and dried with absorbent paper number 80 (Tanari, Manacapuru, Amazonas, Brazil). The cementation of the glass fiber post relined was performed with resin cement RelyX U200 (3M / ESPE), according to the manufacturer's guidelines. Afterwards, the specimens were stored at 37 ° C for 24 hours.

Test push-out

For the push-out test, the specimens were fixed to a metal base on the cutting machine (Isomet 1000 Precision Saw, Buehler, Warwick, UK) and then sectioned perpendicularly along the root axis, resulting in 4 slices of approximately 1.5 mm each. Afterwards, the slices were submitted to the push-out test at a speed of 1 mm / min (DL 2000, Emic, São José dos Pinhais, Brazil).

With the formula σ = F / A, in which F = force for specimen rupture (N) and A = adhesive area (mm^2), the bond strength (σ) in Mpa was obtained. The adhesive area was determined with the formula used to calculate the lateral area of a straight circular cone with parallel bases. The formula being defined as A = $\pi . g . (R1 + R2)$, where π = 3.14, g = adhesive surface, R1 = smaller radius, and R2 = larger radius. The adhesive area was determined with the following calculation:

$$\boldsymbol{g^2 = h^2 + [R2 - R1]^2}$$

The internal diameters of the root canal are obtained by measuring R1 (minor base) and R2 (major base), and h is the sectioned height. A digital caliper (Starrett 727; Starrett, Itu, São Paulo, Brazil) was used to measure the diameters and height (h) of each slice.

For fractographic analysis, the specimens will first be visualized in a stereomicroscope (Stereomicroscope Discovery V20; Carl Zeiss, Germany) under 10x increase. The failures will be classified as: adhesive between cement and dentin (Ades C/D); adhesive between cement and composite resin (Ades C/RC); adhesive between post and composite resin (Ades P/RC); mainly cohesive in some material or dentin (Coes).

Data analysis

The data were analyzed for normality and homogeneity, and parametric testes were applied. Two-way ANOVA was performed to analyze the influence of the post-space treatment and the post-endodontic waiting time on bond strength off glass fiber post relined to root canal dentin. One-way ANOVA was performed to compare post-space treatment teeth with the same post-endodontic waiting time and t-test to compare post-endodontic waiting time with the same post-space treatment.

RESULTS

Post-space treatment and post-endodontic waiting time showed influence on the bond strength of glass fiber post relined with resin composite to root canal dentin (Table 2). When comparing the post-space treatment, the group alcohol/24 hours showed the highest push-out bond strength and had a statistically significant difference with the diode laser/24 hours group. The others post-space treatments showed no statistically significant difference between them (Table 3).

Comparing post-endodontic waiting time between the same post-space treatment, it was found that the 24 hours post-endodontic waiting time groups showed the highest values of push-out bond strength when compared with groups 6 months post-endodontic waiting time, with a statistically significant difference between them (Table 3).

The failure mode was described in the Table 4. Most failures were adhesive between cement and dentin on the groups distilled water, NaOCl 2,5%+EDTA 17%, alcohol, regardless of the post-endodontic waiting time. The group diode laser showed more failures between cement and composite resin.

DISCUSSION

This study showed that different post-space treatments and post-endodontic waiting time influence on the bond strength of glass fiber post relined with resin composite to root canal dentin. Therefore, the null hypothesis was rejected.

The adhesion between the glass fiber post and the root dentin can be affected by the presence of smear layer, composed of remains of dentin, gutta percha and endodontic cement, generated during the preparation of the post-space (2,6). The smear layer can act as a physical barrier, so its removal becomes essential for clinical success (19). The adhesion of the composite resin used to reline glass fiber post, can also suffer influences the presence of smear layer in the dentinal tubules (20). Numerous treatments have already been proposed in order to promote an adequate cleaning of the root canal after preparing the post-space (8-10) and with this a better penetration of cement into dentinal tubules (6,21).

Sodium hypochlorite is one of the most used post-space treatments (6,12), due to its ability to dissolve organic tissues and antimicrobial capacity (6,18,20). EDTA, on the other hand, promotes the decalcification of inorganic components through its chelating action (18,20). Some studies suggest that the union of these two agents may favor the cleaning of the root canal (18,22). In our study, the combination of these solutions presented results similar to the others treatments proposed, when the post-endodontic waiting time was 24 hours (Table 3). An explanation for this result may be due to the deproteinization caused by the hypochlorite, added to the erosion generated by EDTA (18).

On the other hand, in our study the use of alcohol to post-space treatment, in the group 24 hours, showed the highest bond strength values when compared to the others treatments. This may be due to the reduction in hydrophilicity in dentin caused by alcohol (23,24). The greater durability of the bonding of resin cement to dentin may occur due to its composition, which is based on hydrophobic monomers (more chemically and mechanically stable) (23,24). Therefore, when using alcohol as a post-space treatment, it reduces the hydrophilicity of the dentin, favoring the bond strength of glass fiber post relined to root canal dentin.

The diode lasers have an optical thin fiber that can penetrate along the root canal and promote a bactericidal effect (25- 27). On the other hand, the 980 nm wavelength of the diode laser is in the near-infrared portion of the spectrum, which part of the energy is absorbed by the dentin's mineral structures (carbonate and phosphate) promoting fusion in the dental tissue and thermochemical ablation (28). With closed dentinal tubes, due to the thermochemical ablation promoted by the diode laser, the penetration of the resin cement becomes compromised and consequently there is a reduction of the bond strength of glass fiber post relined to root canal dentin (29,30). The post-space treatment with the diode laser, in this study, obtained the lowest values of bond strength when comparing with the others groups, regardless of post-endodontic waiting time. This may occur due to this change that the laser can promote in the composition of root dentin.

The presence of endodontic cement in dentinal tubules can also interfere in the adhesion of the composite resin used to make the glass fiber post relined to root canal dentin (31). In this study, the endodontic cement used was the new bioceramic cement (Bio-C Sealer, Angelus, Londrina, PR, Brazil). This sealer composed of calcium silicates, calcium aluminate, calcium oxide, zirconium oxide, iron oxide, silicon dioxide and dispersing agent. It is a bioactive material because it stimulates the formation of mineralized tissue through the release of calcium ions (32). As a major disadvantage, this cement is difficult to remove from the root canal when there is a need for retreatment or preparation for the post-space (33).

The post-endodontic waiting time have an influence on the bond strength of glass fiber post relined to root canal dentin. The bond strength values were higher in the groups in which the post was cemented after 24 hours of endodontic treatment compared to the groups in which the post was cemented after six months of endodontic treatment, with a statistical difference between them. Agreeing with studies in the literature that show that the adhesion is affected due to the long contact of the endodontic cement with the dentinal tubes which favors its penetration (5,34).

The most common failure observed after the push-out test was between cement and root dentin, in group where the post-space treatment was distilled water. This may have occurred due to incomplete removal of the smear layer, after the preparation of the post-space. This result corroborating of results the other studies in the literature (3,5).

Although studies have shown the similarity between bovine teeth and human teeth, the use of bovine teeth may have been a limitation of this study. However, there is similarity with human teeth in the adhesion tests (35). Thus, new studies evaluating the influence of endodontic cements on the adhesion of the glass fiber post relined to the root canal of human teeth are necessary. In addition, studies evaluating others post-space treatments and in a longer storage period are essential.

CONCLUSION

In conclusion, our findings indicate that the post-space treatment and post-endodontic waiting time influence on the bond strength of glass fiber post relined to root canal dentin. The use of alcohol as a post-space treatment showed to be a good alternative for clinicians when cleaning the root canal, in order to promote an increase in the bond strength of glass fiber post relined to root canal dentin. The waiting time for cementing the glass fiber post relined after endodontic treatment showed better results when performed in 24 hours.

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Tables

Table 1 – Study design.

Treatments for cleaning the post space	Waiting time after endodontic treatment
Distilled water	24 h
NaOCl 2,5%+EDTA 17%	24 h
Alcohol - 99%	24 h
Diode laser	24 h
Distilled water	6 months
NaOCl 2,5%+EDTA 17%	6 months
Alcohol - 99%	6 months
Diode laser	6 months

Table 2 – Two-way ANOVA.

Tests of Between-Subjects Effects

Dependent Variable: Resistencia					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	358.414[a]	7	51.202	11.150	.000
Intercept	3311.966	1	3311.966	721.213	.000
Time	272.429	1	272.429	59.324	.000
Post-space treatment	83.253	3	27.751	6.043	.001
Time * Post-space treatment	2.579	3	.860	.187	.905
Error	316.863	69	4.592		
Total	4042.346	77			
Corrected Total	675.277	76			

a. R Squared = .531 (Adjusted R Squared = .483)

Table 3 – Means (MPa) and standard deviations (± SD) of the push-out bond strength

Post-space treatment teeth	Post-endodontic waiting time	
	24 hours	**6 months**
Distilled water	8.07 ± 1.46 ABa	4.87 ± 1.81 Ab
NaoCl+EDTA	8.25 ± 2.29 ABa	4.40 ± 0.87 Ab
Alcohol	10.27 ± 3.53 Aa	6.07 ± 3 Ab
Diode Laser	7.26 1.29 Ba	3.41 1.14 Ab

Same capital letter indicates no significant differences (columns) for post space treatment teeth with the same post-endodontic waiting time. Same lowercase letter indicates no significant differences (lines) for post-endodontic waiting time with the same post-endodontic treatment.

Table 4 - Failure mode distribution after the push out test.

Post space treatment	**Post-endodontic waiting time**	**Failure's type**				
		Adhes c/d	Adhes c/rc	Adhes p/rc	Coes	Total
Distilled water	24 h	33	-	-	7	40
	6 months	37	-	-	3	40
NaOCl 2,5%+EDTA 17%	24 h	26	-	-	14	40
	6 months	28	-	1	6	35
Alcohol	24 h	26	-	1	13	40
	6 months	28	-	-	12	40
Diode Laser	24 h	-	35	3	2	40
	6 months	-	33	-	7	40
	Total	178 (56.5%)	68 (21.6%)	5 (1.6%)	64 (20.3%)	315 (100%)

Adhes c/d = adhesive between cement and dentin; Adhes c/rc = adhesive between cement and composite resin; Adhes p/rc = adhesive between post and composite resin; Coes = mainly cohesive in some material or dentin.

4. DISCUSSÃO

O uso dos pinos de fibra de vidro para restaurar dentes tratados endodonticamente tornou-se popular devido as suas propriedades estéticas, por apresentar biocompatibilidade e, também por proporcionar redução no tempo clínico (FIGUEIREDO; MARTINS-FILHO; FARIA-E-SILVA, 2015; ERIK et al., 2020). Além disso, os pinos de fibra de vidro apresentam módulo de elasticidade semelhante à dentina, o que reduz o risco de fratura radicular (ERIK et al., 2020). O pino de fibra pode apresentar-se desadaptado quando utilizado em canais ovais ou alargados, o que pode prejudicar a sua adesão ao canal radicular (ROCHA et al., 2017; MACHRY et al., 2020), assim como ocasionar um maior número de fraturas radiculares (BAKAUS et al., 2018; DE SOUZA et al., 2016; WEBBER et al., 2018).

A fim de melhorar essa condição surgiram os pinos anatômicos, que são pinos reembasados com diversos tipos de materiais (GRANDINI; SAPIO; SIMONETTI, 2003; WEBBER et al., 2018). Com o surgimento de novos materiais que podem ser utilizados para a confecção do pino anatômico e, devido a escassez de estudos nessa área, surgiu o primeiro artigo dessa tese, intitulado "**Does glass fiber post relining material influence tooth fracture resistance?"**, que teve como objetivo avaliar a resistência à fratura de dentes tratados endodonticamente restaurados com pinos de fibra de vidro reembasados com diferentes materiais.

Nesse estudo os materiais utilizados para a confecção do pino anatômico foram: as resinas compostas Z250 XT, Z350 XT, One Bulk Fill, One Bulk Fill flow, e o cimento resinoso Allcem Core. Os resultados mostraram que os diferentes materiais utilizados, para reembasar o pino de fibra de vidro, não influenciaram a resistência à fratura de dentes tratados endodonticamente. Esse achado pode ter ocorrido devido a similaridade na composição e nas propriedades mecânicas dos materiais utilizados. Também, o padrão de falha foi similar entre os grupos, sendo o grupo controle – sem reembasamento do pino - o que apresentou mais falhas desfavoráveis, possivelmente resultantes da grande espessura de cimento.

A relevância dos resultados encontrados no primeiro artigo está na sua grande aplicabilidade clínica, visto que devido a similaridade dos materiais utilizados no estudo, o cirurgião-dentista pode utilizar o material de mais fácil manipulação ou o material disponível durante o procedimento clínico. Nesse contexto, em nosso estudo, devido a alta porcentagem de partículas de carga presentes na composição, a resina Z250 XT mostrou-se mais fácil de manipular durante a confecção do pino anatômico. Novos estudos devem ser conduzidos, visto que alguns materiais analisados na presente pesquisa são relativamente novos, e há poucos estudos avaliando o seu comportamento quando utilizados para reembasar pinos de fibra de vidro (BAKAUS et al., 2018; FARIA-E-SILVA et al., 2009).

O segundo artigo, intitulado **"Can post-space treatment and post-endodontic waiting time influence on the bond strength of glass fiber post relined to root canal dentin?"**, objetivou avaliar a influência do tratamento do espaço para o pino e do tempo de espera para a cimentação do pino após o tratamento endodôntico na resistência de união do pino anatômico à dentina do canal radicular. Após grande pesquisa, esse estudo se tornou pertinente visto que há poucos estudos avaliando a influência do tratamento do espaço para o pino utilizando pinos anatômicos (CECCHIM et al., 2011; CECCHIN et al., 2014a; CECCHIN et al., 2014b; DE OLIVEIRA et al., 2018).

Os tratamentos de escolha para a limpeza do espaço para o pino nesse estudo foram: água destilada, NaOCl 2,5% + EDTA 17%, álcool 99%, laser de diodo, já o tempo de espera para a cimentação do pino anatômico foi de 24 horas e seis meses. Os resultados mostraram que tratamento do espaço para o pino, assim como o tempo de espera após o tratamento endodôntico para a cimentação do pino anatômico influenciaram na resistência de união do canal radicular ao pino anatômico.

O tratamento para o espaço do pino realizado com álcool 99%, no tempo de espera de 24 horas, apresentou os maiores valores de resistência de união em comparação com os demais tratamentos propostos no estudo. O tratamento utilizando álcool 99% pode ter ocasionado uma redução na hidrofilicidade da dentina (DOS SANTOS et al., 2017; SADEK et al., 2008), consequentemente favorecendo a resistência de união do pino ao canal radicular, visto que a composição do cimento resinoso é baseada em monômeros hidrofóbicos (DOS SANTOS et al., 2017; SADEK et al., 2008).

Já, o hipoclorito de sódio, tratamento do espaço para o pino mais utilizado clinicamente (AKMAN. Et al., 2016, MARTINHO et al., 2015), quando utilizado em combinação com o EDTA 17% apresentou, em nosso estudo, resultados semelhantes aos demais tratamentos, no tempo de espera de 24 horas. Isso pode ter ocorrido devido a desproteinização causada pelo hipoclorito na dentina radicular, somada a erosão gerada pelo EDTA (GARCIA et al., 2018).

O laser de diodo utilizado num comprimento de onda de 980 nm tem parte da sua energia absorvida estruturas minerais da dentina (carbonato e fosfato) promovendo fusão no tecido dentário e ablação termoquímica (ALFREDO et al., 2009). Provavelmente, devido a essa alteração causada pelo laser de diodo, nesse estudo, os grupos que utilizaram o laser de diodo apresentaram os menores valores de resistência de união em comparação com os demais tratamentos, independentemente do tempo de espera para a cimentação do pino anatômico.

O tempo de espera após o tratamento endodôntico para a cimentação do pino, também teve influência na resistência de união da dentina do canal radicular ao pino anatômico. Os grupos em que o pino foi cimentado após 24 horas do tratamento endodôntico apresentaram maiores valores de resistência de união em comparação com os grupos em que o tempo de espera foi de 6 meses. Esses resultados vão ao encontro de outros estudos que avaliaram o tempo de espera (BOHRER et al., 2018; ALTMANN; LEITUNE; COLLARES, 2015)

Além disso, ao analisarmos os diferentes tipos de falhas ocorridas no estudo, foi visto que a falha mais comum ocorreu entre o cimento e a dentina radicular, no grupo que utilizou água destilada como tratamento. A incompleta remoção do smear layer após o preparo para o pino pode justificar esse achado. Outros estudos mostraram resultados semelhantes em relação ao tipo de falha encontrada (BOHRER. et al., 2018; PARCINA et al., 2016).

Como limitações da presente tese, pode-se ressaltar o uso de dentes bovinos, apesar de haver similaridade com os dentes humanos nos testes de adesão (SOARES et al., 2016). Assim, considerando os achados na presente tese, faz-se necessário a condução de novas pesquisas *in vitro* e *in vivo* avaliando a utilização de diferentes materiais para a confecção dos pinos anatômicos, bem como diferentes tratamentos para a limpeza do espaço para o pino anatômico.

5. CONCLUSÃO

Baseado nos achados da presente tese, pode-se concluir que:

- Dentre os materiais utilizados para o reembasamento do pino de fibra de vidro, em nosso estudo, foi concluído que os mesmos apresentam resistência à fratura semelhantes entre si. Por isso, a escolha do material para confeccionar o pino anatômico pode ser feita através da preferência do cirurgião-dentista, assim como pela disponibilidade do material presente na clínica no momento do procedimento.

- O tratamento de limpeza do espaço para o pino, assim como o tempo de espera para a cimentação do pino anatômico após o tratamento endodôntico influenciaram na resistência adesiva do pino anatômico a dentina radicular. O tratamento do espaço para o pino utilizando álcool, após 24 horas do tratamento endodôntico mostrou-se a melhor opção clínica, na presente tese.

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a. The paragraph is the ideal unit of organization. Paragraphs typically start with an introductory sentence that is followed by sentences that describe additional detail or examples. The last sentence of the paragraph provides conclusions and forms a transition to the next paragraph. Common problems include one-sentence paragraphs, sentences that do not develop the theme of the paragraph (see also section "c," below), or sentences with little to no transition within a paragraph.

b. Keep to the point. The subject of the sentence should support the subject of the paragraph For example, the introduction of authors' names in a sentence changes the subject and lengthens the text. In a paragraph on sodium hypochlorite, the sentence, "In 1983, Langeland et al, reported that sodium hypochlorite acts as a lubricating factor during instrumentation and helps to flush debris from the root canals" can be edited to: "Sodium hypochlorite acts as a lubricant during instrumentation and as a vehicle for flushing the generated debris (Langeland et al, 1983)." In this example, the paragraph's subject is sodium hypochlorite and sentences should focus on this subject.

c. Sentences are stronger when written in the active voice, that is, the subject performs the action. Passive sentences are identified by the use of passive verbs such as "was," "were," "could," etc. For example: "Dexamethasone was found in this study to be a factor that was associated with reduced inflammation," can be edited to: "Our results demonstrated that dexamethasone reduced inflammation." Sentences written in a direct and active voice are generally more powerful and shorter than sentences written in the passive voice.

d. Reduce verbiage. Short sentences are easier to understand. The inclusion of unnecessary words is often associated with the use of a passive voice, a lack of focus, or run-on sentences. This is not to imply that all sentences need be short or even the same length. Indeed, variation in sentence structure and length often helps to maintain reader interest. However, make all words count. A more formal way of stating this point is that the use of subordinate clauses adds variety and information when constructing a paragraph. (This section was written deliberately with sentences of varying length to illustrate this point.)

e. Use parallel construction to express related ideas. For example, the sentence, "Formerly, endodontics was taught by hand instrumentation, while now rotary instrumentation is the common method," can be edited to "Formerly, endodontics was taught using hand instrumentation; now it is commonly taught using rotary instrumentation." The use of parallel construction in sentences simply means that similar ideas are expressed in similar ways, and this helps the reader recognize that the ideas are related.

f. Keep modifying phrases close to the word that they modify. This is a common problem in complex sentences that may confuse the reader. For example, the statement, "Accordingly, when conclusions are drawn from the results of this study, caution must be used," can be edited to "Caution must be used when conclusions are drawn from the results of this study."

g. To summarize these points, effective sentences are clear and precise, and often are short, simple and focused on one key point that supports the paragraph's theme.

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The authors deny any conflicts of interest related to this study.

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