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MESTRADO PROFISSIONALIZANTE EM ODONTOLOGIA

OSCAR JOÃO KLÜPPEL NETO

EFEITO DO COMPRIMENTO DOS PINOS DE FIBRA DE VIDRO E DA ESTRATÉGIA ADESIVA PARA A RESTAURAÇÃO DE CANINOS EXTENSAMENTE DESTRUÍDOS

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Dissertação apresentada ao Centro Universitário Ingá UNINGÁ, como parte dos requisitos para a obtenção do título de Mestre em Odontologia, subárea Prótese Dentária.

Orientadora: Profª. Drª. Nubia I. Pavesi Pini

MARINGÁ

2019

DEDICATÓRIA

Dedico este trabalho...

*Primeiramente **a Deus**, o doador e mantenedor da vida, Aquele que derramou tantas bênçãos sem que eu merecesse. Agradeço-lhe por mais esta benção de concluir este sonho tão almejado. A Ti toda honra e Glória.*

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RESUMO

RESUMO

Pinos de fibra de vidro (PFV) constituem uma opção para restauração de dentes extensamente destruídos e sem férula, ainda que haja controvérsias em relação a sua utilização. No entanto, as estratégias adesivas atuais permitem que a cimentação de PFV seja cada vez mais conservadora. Esse estudo avaliou diferentes comprimentos de pino e diferentes cimentos resinosos para a restauração de caninos humanos extensamente destruídos. Sessenta caninos humanos foram coletados e utilizados na pesquisa, divididos em dois grupos de acordo com a cimentação adesiva utilizada (N=30) – cimento autoadesivo ou cimento convencional. Cada grupo foi subdividido de acordo com o comprimento intracanal do PFV: 10 mm, 7.5 mm e 5 mm (n=10). Para a cimentação, a porção radicular dos caninos foi tratada endodonticamente e seu conduto foi alargado para simular uma condição de destruição juntamente com a ausência de férula. A reconstrução coronária foi realizada com resina composta. Os espécimes foram incluídos para a simulação do ligamento periodontal e submetidos a fadiga mecânica (160N – 1.200000 de ciclos) e ao teste de resistência a fratura. Os resultados foram submetidos a analise de variância (ANOVA) e ao teste de Tukey (α=5%). Não houve diferença significante entre os comprimentos de pino e entre as estratégias de cimentação ($p>0.05$). A cimentação com PFVs de 7.5 mm de comprimento resultou em maior número de fraturas catastróficas. O comprimento dos pinos não influencia a resistência a fratura da restauração. Cimentos autoadesivos e convencionais podem ser utilizados para a cimentação de PFVs.

Palavras-chave: pinos de fibra de vidro, resistência a fratura, fadiga.

ABSTRACT

ABSTRACT

GLASS FIBER POST LENGTH AND ADHESIVE STRATEGY TO RESTORE EXTENSIVELY DAMAGED CANINES

STATE OF PROBLEM: Glass fiber posts (GFPs) are an option for restoring extensively damaged teeth without a ferrule, even though there are some controversies concerning this issue. However, recent adhesive strategies have provided a more conservative technique for GFPs.

PURPOSE: This study evaluated different post lengths and adhesive strategies for restoring extensively damaged human canines.

MATERIAL AND METHODS: Sixty human canines were collected and divided into two groups (N=30), according to the resin cement used – self-adhesive or conventional. Each group was subdivided into 3 groups (n=10) based on the intracanal post length: 10 mm, 7.5 mm and 5 mm. For cementation, the radicular portion was endodontically filled and the cervical third was enlarged to simulate extensive damage. The coronal portion was reconstructed with composite resin. The samples were prepared with a simulated periodontal ligament and were submitted to fatigue loading (160N – 1.200,000 cycles) and fracture resistance testing (0.5 mm/min using a load cell of 5000N). The results were analyzed by ANOVA and Tukey tests (α=5%).

RESULTS: There was no statistical difference among the post lengths tested ($p>0.05$). However, the performance of the conventional cements was better than the self-adhesive cements when the same post length was compared ($p<0.05$). Repairable fractures were prevalent (70-90%) in all groups tested.

CONCLUSIONS: The post length did not influence the fracture resistance of the restoration. Conventional cements using an MDP-based adhesive showed better results when compared to a self-adhesive cement.

Keywords: glass fiber post, fracture resistance, resin cements.

SUMÁRIO

INTRODUCTION

1 INTRODUCTION

Glass fiber posts (GFP) are an option for restoring endodontically treated teeth with extensive damage. Currently, GFPs are an alternative to metallic posts, since they allow the use of adhesive strategies, using composite materials to adhere the GFPs to dentin.[1-3] The GFP restoration has advantages in relation to metallic posts, including: the GFPs have a modulus of elasticity similar to dentin; the technique is conservative, since it does not require extensive tooth preparation; and GFP placement may be performed in a reduced clinical time, allowing the immediate sealing of the root canal.[1,4]

Currently, the indication for intracanal retainers, such as GFPs, has diminished. This is a newer trend due to the current understanding about tooth adhesion; mainly, that the retention of materials on tooth structure is due to the interaction with the remaining dentin – at least 2 mm of circumferential ferrule.[1,5,6] In cases where these tissues are present, the tooth preparation for a GFP may weaken the dental structure.[7,8] However, there are situations where the mechanical retention provided by an GFP, as in cases of extensively damaged and endodontically treated teeth without ferrule, is beneficial.[4] In these situations, glass fiber posts are an excellent alternative to cast post and cores.[9] Moreover, even in this situation, there is now the possibility for greater conservation due to an updated adhesive strategy available for this situation, utilizing self-adhesive cements and the newer multimode adhesives containing 10-methacryloyloxydecyl (MDP);[10] or reducing the tooth preparation, using shorter and re-embased posts.[11] The possibility of using shorter posts is advantageous, since it reduces tooth preparation, consequently reducing the risk of root perforation; it provides visualization of the prepared root; and it optimizes photopolymerization inside the root.[11,12]

The GFP acts as a retainer for the composite resin/ceramic restorations and promotes a better distribution of the occlusal stresses through the remaining tooth structure.[4] In this sense, a concern of the technique is the length of the GFP, which was firstly suggested to be 2/3 of the intracanal length, as indicated for metallic posts. However, with the adhesive possibilities and the intention to promote more conservative techniques, some studies have purposed modifications in the GFP technique, such as using shorter posts[11] or not using them.[7,8] Although several studies do not recommend the use of GFP in the literature,[7,8,13] they are all laboratorial and oppose the available clinical studies, which show that restorations with GFPs present longevity with a low incidence of fractures, which are easily repairable when necessary.[14-16] Additionally, systematic reviews do not show a negative effect of the post when appropriately indicated.[17,18]

Regarding these data, modifications in the GFP technique are important to be considered and studied, since it is still a frequently performed technique. The purpose of this study was to test different options for cementation of GFPs in extensively damaged and endodontically treated permanent canines. The factors under study were length of the post and adhesive strategy. The null hypotheses were that there would be no difference between the post length (1) and cements used (2) for the GFP technique in relation to fracture resistance.

MATERIAL AND METHODS

2 MATERIAL AND METHODS

This study used human permanent canines extracted under indication that were stored in 0.5% chloramine solution for a maximum period of 6 months. The study was approved by the Ethical Committee (CAAE 09673019.8.0000.5220) and the donors signed an informed consent. The teeth used follow the inclusion criteria that included: absence of caries or root cracks; absence of previous endodontic treatments, posts, or crowns; and a root length of at least 15 mm, which was the standardized dimension used for the experiment. Additionally, teeth similar mesio-distal and bucco-lingual dimensions were selected. The crowns were sectioned from all specimens to simulate the absence of ferule and the cervical third of the root was enlarged to simulate extensive damage to be restored. The teeth were distributed into 6 experimental groups with 10 samples each, varying the length of the post and the resin cement used to restore them. The factors (3x2) of study were fiber post length (5 mm, 7.5 mm and 10 mm) and the cementation strategy (self-adhesive or conventional cements). The specimens were submitted to fatigue loading and the fracture resistance was tested. The study design is presented in Figure 1.

Figure 1. Design of the study

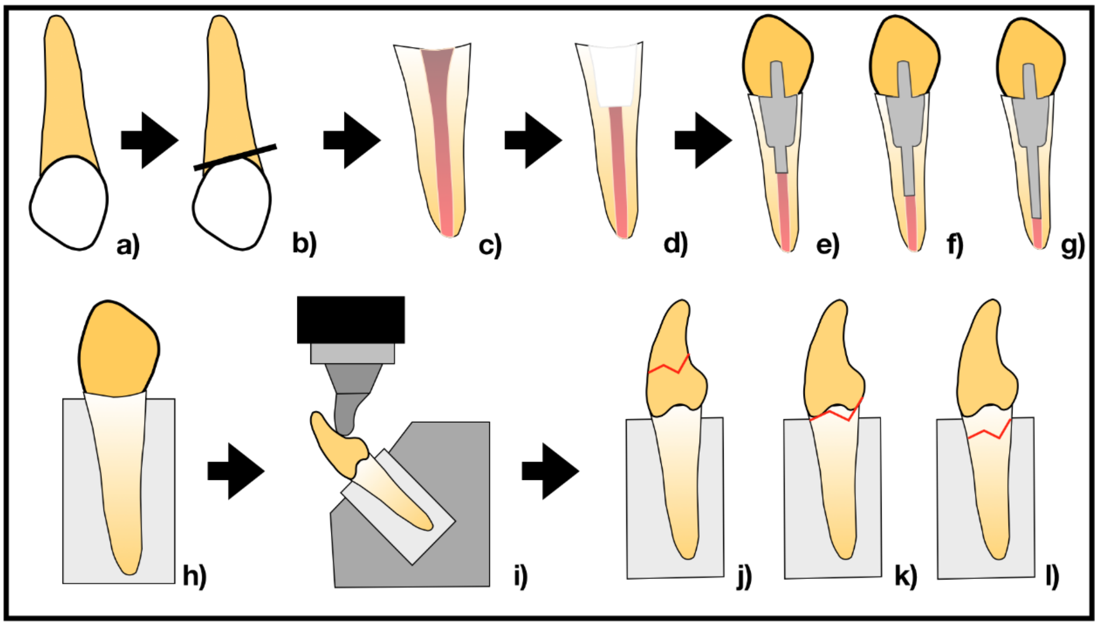


Figure 1. Design of the study: a) Canines selected for the study; b) Root-crown separation to obtain the roots; c) roots with endodontic treatment; d) simulation of extensive damage in the cervical third; e)/f)/g) cementation of the GFP in the respective length and coronary reconstruction with composite resin; h) inclusion of the samples and simulation of periodontal ligament; i) fatigue and fracture resistance tests; j)/k)/l) analysis of fracture resistance.

Specimen preparation

- Endodontic treatment

The teeth were cut at the most apical point of the cement-enamel junction using a low-speed and precise diamond saw (Isomet 1000, Buehler) to be decoronated. Then, endodontic treatment was performed using the crown-down technique with the Pro-Taper system (Maillefer, Dentisply). The apical third was prepared up to a 30-file size, irrigation was performed after each new file, alternating between 2.5% NaOCl solution and 17% EDTA solution. After drying with paper points, the roots were sealed using Endofill cement (Dentsply) and gutta-percha points (Tanari; Tanariman Industrial LTDA). The root access was temporarily filled with glass ionomer cement (Maxion R, FGM Products).

- Preparation of root canal

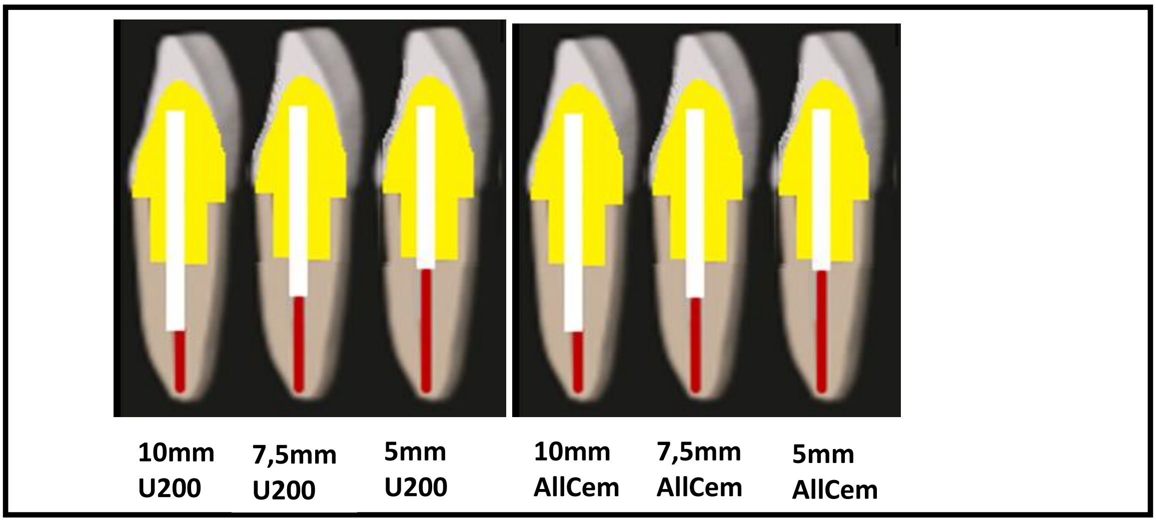
The 2, 3 and 4 Gates-Glidden burs were used to promote root obturation. The low-speed bur specific for the post used (0.5 DCE, FGM Products, Joinvile, SC, Brazil) for root preparation was used to create the depth of post space, according to the experimental groups varying the post-core ratio (n=20):

a) 5 mm: 1:1 proportion between the length of the post inside the root canal and its coronal part;

b) 7.5 mm: 3:2 proportion between the length of the post inside the root canal and its coronal part;

c) 10 mm: 2:1 proportion between the length of the post inside the root canal and its coronal part;

Figure 2. The Length of the Post



The cervical third (4 mm) of the roots was enlarged using a tapered bur (Fresa Tungstenio Maxicut, Ref. 1512, American Burs), creating extensive damage in this region. To be standardized, the surrounding walls were maintained with a thickness of 1 mm, resulting in a vestibular-pallatal distance of 7 mm and in a distal-mesial distance of 4 mm (Figure 2). All of the dimensions were assessed using a digital paquimeter (Mitutoyo Sul América Ltda).

- Luting and restorative procedures

Before cementation, all the fiber posts (White Post DCE, FGM Products) were relined using composite resin (Vitra A2, FGM Products) to better fit with the root canal anatomy, to reduce the cementation interface and to resist to mechanical forces.[19,20] First of all, the post surface was cleaned with ethanol and the silane coupling agent (Prosil, FGM Products) was applied and allowed to react for 60 seconds. Then, the adhesive (Ambar, FGM Products) was applied over the silanized post and light cured for 20 seconds (VALO Standard mode – 1000 mW/cm^2 – Ultradent Products Inc.). Afterwards, the canal walls were lubricated with a hydrosoluble gel; the fiber post was covered with a microhybrid composite resin and inserted into the canal. The composite resin was light cured for 5 seconds, the relined fiber post was removed, and the resin composite was light cured again for 40 seconds.

Figure 3. Design of the prepared tooth

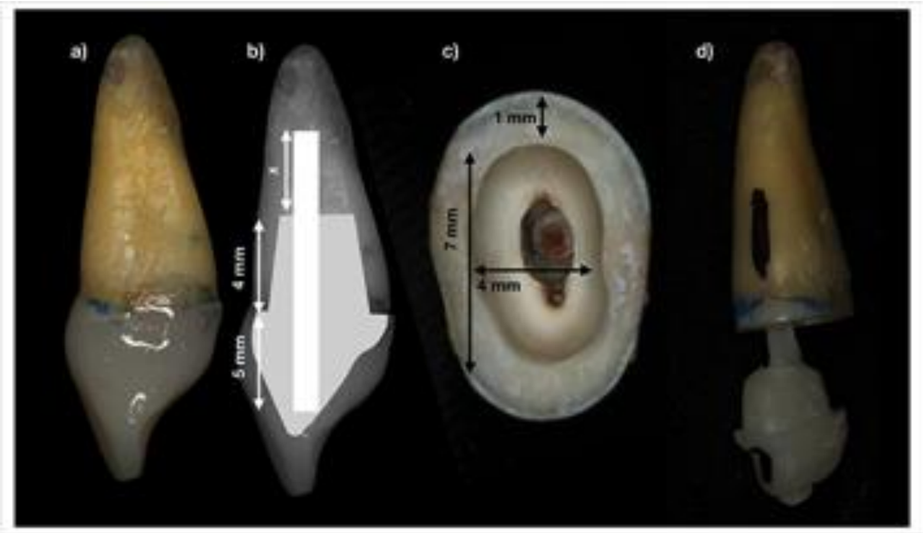


Figure 3. Root canal preparation design: a) Permanent canine after post cementation and coronary reconstruction; b) Scheme of the dimensions of the enlarged cervical third, the coronary portion of the post and, x, the middle/apical portion of the post (being 1, 2.5 or 5 mm); c) View of the root configuration; d) Post prepared previously the cementation.

In each experimental group varying the post length, the specimens were distributed according to the strategy of cementation (n=10). Two adhesive techniques were used for the cementation of the relined posts: Self-adhesive cement (Rely X U200, 3M ESPE) and conventional etch-and-rinse cement (Allcem Core, FGM Products). Information about the products and the techniques used are in Table 1. The manufacturers' instructions were followed for cementation. Prior to cementation, the relined post had its surface cleaned with alcohol followed by the application of a silane agent (Prosil, FGM Products). For the conventional etch-ad-rinse cement (AllCem Core, FGM Products), the radicular portion was treated with phosphoric acid 37% (Condac 37%, FGM Products) for 15 seconds, which was rinsed and dried; followed by the application of the conventional adhesive (Ambar, FGM Products) and application of the cement using a specific syringe. Afterwards, the anatomized post was positioned and photoactivated for 5 seconds for the preliminary removal of the excess cement. The light curing was then performed for 40 seconds with the before mentioned lightcuring unit (VALO, Ultradent Products Inc.) positioned at each face of the post (buccal, palatal, mesial and distal). For the self-adhesive cement, the same procedure was repeated, excluding the phosphoric acid etching and the application of the adhesive in the radicular portion and including irrigation with hypochlorite prior to cementation. Afterwards, the coronal portion of each specimen was reconstructed. For this procedure, a standardized canine crown-matrix in acetate was used as a matrix for the tooth reconstruction using a composite resin (Vitra, FGM Products) and the conventional etch-and-rinse technique. Composite resin was applied in layers with a maximum thickness of 2 mm for each of them; each increment was polymerized for 40 seconds. Finishing and polishing were performed immediately after polymerization of the composite core using fine diamond burs and finishing discs.

Table 1. Resin cements and adhesive strategy used for cementation and coronary reconstruction

Material/Application	Composition	Manufacturer
White Post DCE – Glass Fibre Post (020118)	Fiber Glass, Epoxy resin, radiopaque compound, inorganic load, polymerization promoters	FGM
Rely-X U200 – Dual cure self-adhesive universal resin cement for post cementation	Base: fiberglass, esters, phosphoric acid, methacrylate, triethylene glycol dimethacrylate (TEGDMA), silanated silica and sodium persulfate, inorganic fillers (45% wt). Catalyst: fiberglass, substitute dimethacrylate, silanated silica, sodium p-toluenesulfonate and calcium hydroxide.	3M ESPE
AllCem Core – conventional resin cement for post cementation (150817)	Base paste: methacrylate monomers (such as TEGDMA, BisEMA e BisGMA), Canforoquinona, co-initiators, Barium-Aluminum-Silicate glass micro-particles and nano-particles of silicon dioxide	FGM

	(68% wt), inorganic pigments and conservants. Catalyst paste: methacrylate monomers, dibenzoyl peroxide, stabilizers and Barium-Aluminum-Silicate glass micro-particles.	
Ambar Adhesive (060917)	Active Ingredients: MDP (10-methacryloyloxydecyl dihydrogen phosphate), methacrylic monomers, photoinitiators, coinitiators, stabilizers. Inactive Ingredients: Inert load (Silica nanoparticles) and vehicle (ethanol)	FGM
Vitra A2 – composite resin used for relining the post and core reconstruction (181017)	Active ingredients: monomeric matrix containing monomers of the types UDMA (Urethane Dimethacrylate) and TEGDMA (Triethylene Glycol Dimethacrylate), photo-initiating composition (APS), coinitiators, stabilizer and silane. Inactive ingredients: Load of Zirconia, silica and pigments.	FGM
Prosil – Silane used for post silanization	3-Metacriloxipropiltrimetoxisilano (teor:< 5%); Ethanol (teor: > 85%); Water (teor:< 10%)	FGM
Phosphoric acid 37%-Condac 37 (240118)	Phosphoric acid at 37%, thickener, pigment and deionized water	FGM

- Periodontal ligament simulation

To simulate the periodontal ligament,[21] root surfaces were dipped in melted wax (Epoxiglass) up to 2.0 mm below the CEJ, resulting in a 0.2 to 0.3 mm thick wax layer. The root was then positioned at the center of a plastic cylinder (Tigre, Rio Claro, SP, Brazil) with a 5 mm diameter, containing acrylic resin (Jet Clássico), positioned with a 30º inclination. The roots were embedded in resin up to 2 mm below the cemento-enamel junction (CEJ). After resin polymerization, the teeth were removed from the cylinder, and the wax was removed from the root surface and resin cylinder. The teeth were embedded in a polyether impression material (Impregum F, 3M ESPE). The elastomeric material was manipulated according manufacturing instructions and placed in the resin cylinders. The teeth were reinserted into the cylinder and the excess elastomeric material was removed using a scalpel blade (Xishan Medical Instrument).

Fatigue loading

The specimens were submitted to a fatigue load of 1.200,000 cycles under 100% humidity at 37ºC using a chewing simulator (ERIOS 11000 Plus)[11] to simulate 5-years of clinical use.[22] With the samples containing a simulated periodontal ligament, the load was applied at 45º from the cingulus of the canine using a metallic holder of a compatible diameter (2.5 mm). Although the maximum forces on anterior teeth varies, it is always below 200 N. Therefore, a load of 160 N was applied at a frequency of 2 Hz.

Fracture resistance

After fatigue loading, all surviving specimens were immediately subjected to a fracture resistance test using a universal loading device (EMIC, Instron Equipaments). For this test, each specimen was positioned 135º in relation to a 2.5 mm diameter stainless-steel ball-shaped stylus, as determined in a pilot study to better simulate the clinical condition at this moment. This angle reflects the position, contacts, and loading characteristics of upper anterior teeth in Class I occlusion.[3] Each test was performed at a cross-head speed of 0.5 mm/min using a load cell of 5000N and the same holder employed in the fatigue loading. The maximum failure load was recorded in Newtons (N).

Failures were recorded as:

a) Repairable – when the fracture line was located in the crown or above the simulated bone level;

b) Catastrophic – not-repairable – when the fracture line was below the simulated bone level.

Statistical analysis

Statistical analysis was performed using the software SPSS.22 The obtained data was checked and presented normal distribution (Kolmogorov-Smirnov test). The data were then submitted to analysis of variance (two-way ANOVA) and Tukey post-hoc test. The level of significance was set at 5%.

RESULTS

3 RESULTS

None of the specimens fractured during fatigue loading. The post length did not influence the fracture resistance, since the three variables showed statistically similar results (p>0.05). When comparing the adhesive strategy, conventional cements were more effective (p<0.05).

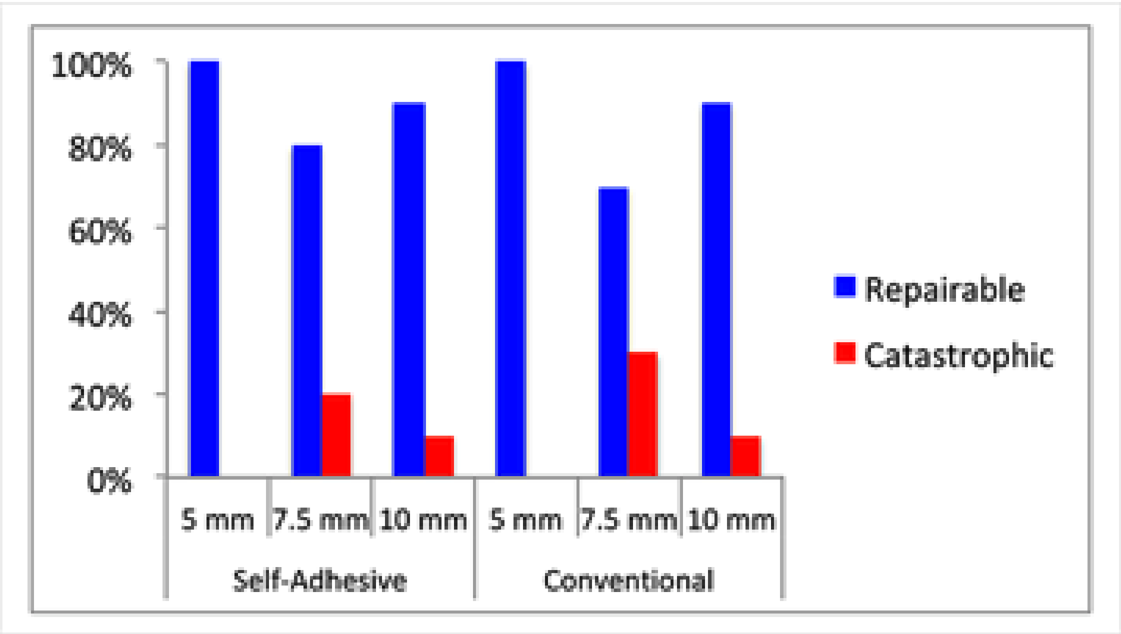
Table 2. Fracture resistance results after fatigue loading

Post lenght	Self-adhesive cement	Conventional cement
10 mm	738.75 (±204.33) Ba	1131.54 (±324.28) Aa
7.5 mm	662.68 (±207.56) Ba	981.46 (±326.16) Aa
5 mm	748.13 (±119.20) Ba	1195.69 (±387.71) Aa

Upper case indicates significant differences between cements (rows). Lower case indicates significant differences between post lengths (columns).

The fracture pattern is presented in Table 3. Catastrophic fractures were more incident in groups with a post length of 7.5 mm. The 5 mm post length resulted only in repairable fractures.

Figure 4. Fracture patter showed for each group of study.



DISCUSSION

4 DISCUSSION

In this study, different lengths of GFPs and adhesive strategies were tested when restoring extensively damaged teeth. To simulate this, permanent canines with no coronal structure and with the cervical third of the root portion enlarged (Figure 2) were used. The primary intention of the study was to test different approaches for the rehabilitation of teeth without using a ferrule. The fatigue loading was performed to better fit with previous results and to allow comparability.[11,14] To the best of the author's knowledge, it is scarce the data available in the literature concerning this issue. In relation to the GFP length, the null hypothesis can be accepted, since differences on fracture resistance between the different GFP lengths were not found. However, concerning the adhesive strategy used, the null hypothesis can be rejected, since conventional and self-adhesive cementation affected the fracture resistance of the different GFPs lengths.

There is currently a concern regarding the indication of GFPs and a discussion of their importance is commonly achieved. Some laboratory results have indicated that GFPs are not necessary in cases of extensive destruction when a 2 mm ferrule is present; a GFP in these cases causes a higher incidence of catastrophic non-repairable failures.[7,8,13,23] On the other hand, clinical results[17] have controversially disagreed with these *in vitro* results. The literature is emphatic in showing that the behavior of GFPs is dependent of several factors, including: the amount of remaining coronal structure, the type and position of the tooth, its relation with its antagonist, the type of restoration and other factors that influence post survival.[6,16-18] A recent systematic review and meta-analysis confirmed that there is no difference between the failure of fiber-reinforced composite post-and-core restorations with or without ferrule,[17] indicating that the GFP is an option for use in cases of extensively destroyed teeth. However, this current study evaluated optimal conditions for the use of a GFP.

Clinically, when a tooth does not have a ferrule but is indicated for rehabilitation, the canal is generally flared from carious extension, trauma, or previous treatment, compromising the adaptation of GFPs. This current study simulated this condition by enlarging the cervical third of the canines up to 4-mm deep, as shown in Figure 2. Even under this extreme situation, GFPs should be preferred since they avoid catastrophic failures.[6] However, in cases of significant missing tooth structure, a thicker layer of cement should be avoided to retain the GFP, which can predispose to de-bonding of the GFP.[24] Therefore, relining the fiber post is a solution to reduce this problem.[20,25] This technique customizes the GFP to fit the root canal geometry and reduces the thickness of the resin cement, decreasing the formation of voids and increases the retention of the modified GFP due to friction with the canal walls.[20,25,26] These are important factors for providing homogeneous distribution of stresses during function along the post-cement-dentine interface.

Previous findings have shown a higher resistance to fracture with greater post lengths,[9,27-31] recommending posts with lengths at least similar to the clinical crown length.[29] The results of this study did not show statistical differences between the post lengths tested, neither for each type of resin cement. Conversely, Zicari et al. (2012)[11] found that shorter posts (5 mm – similar to this study) obtained a fracture resistance superior to that found for 10 mm posts, irrespective of the resin cement used. In accordance with those authors, this may be attributed to a greater preservation of sound dentin at the deeper root level, where the root dentin itself is narrower. The technique should be conservative, avoiding removal of sound dentin. Another factor that impacts this result is the influence of adhesive strategy, since the composite resin cementation improves the fracture resistance, even compared in cases of reduced lengths of metallic posts.[31] Additionally, increased post lengths increase the stress concentration in the apical region, increasing the risk of tooth fractures.[29,30] Differences between the present results and previous results may be related to several factors, such as adhesive strategy, light activation unit used, fatigue load and resistance application, type and condition of the teeth, among other factors. To the best of the author's knowledge, there are no studies in the literature simulating the lack of ferrule and flared human canines. Only one study was found testing central incisors, however, without changing the post length.[32]

With regards to the adhesive strategies, the conventional etch-and-rinse cement showed a better performance when compared to the self-adhesive cement. On the other hand, push-out tests demonstrated similar performances for the two techniques./materials.[10,27,33-35] Some studies reported differences between the different levels of dentin tested,[20,34,35] with the worst bond strength values in the apical third, likely due to the dentin morphology and due to difficulties in the adhesive technique in deeper regions as well. However, since no differences were found between the different post lengths tested in this study, comparisons between these methodologies are not supported.

Since the conditions of this present study are standardized to control the risk of bias (i.e. all of the procedures performed by a single operator under randomized conditions; the use of a translucent and relined post to reduce the thickness of cementation; using a cementation technique following the manufacturing directions), the differences found between the cements are likely due to their compositions. Self-adhesive cements are easier to handle since they do not require the etching step on the dentin surface. They typically contain acidic monomers, which demineralize and infiltrate the superficial dentin, creating micromechanical retention.[36] Additionally, the self-adhesive mechanism consists of an acid-base reaction in which the water is used to activate the monomers and to neutralize the pH of the material.[36-38] On the other hand, conventional cements require a more critical technique which has several steps (acid etching, rinsing and drying of dentin, application of adhesive with correct solvent evaporation followed by application of the cement), which make it more prone to failure. When the protocol is correct followed, the technique is reliable. In this study, the adhesive contains MDP monomer, which chemically bonds its phosphate groups with the hydroxyapatite crystals inside the collagen scaffold.[39] This interaction with MDP monomer is stable over time and seems to be more stable in water.[33,39] This detail might have influenced the present results, since the fatigue testing was performed under humidity.

Another fact is that self-adhesive cements present lower degree of conversion when compared to conventional cements.[40] This is related to the amount of TEGDMA in their composition, which is a diluent monomer. Self-adhesive cement (Rely X U200) shows a viscous formula which may impair the mobility of its functional monomers and radicals to migrate during the polymerization setting.[41] Despite to do not specify the amount of TEGDMA, Rely X U200 probably present reduced amount of this monomer, which implies in its conversion degree,[40] an important factor that is related to several physical properties and clinical performance of resin cements.[42] Another difference between the tested resin cements is the filler content (Rely X U200 – 42% wt and AllCem Core approximately 68% wt). The filler type and content may directly affect the flexural properties and shrinkage behavior of the cement, impacting on its performance.[40] Afterwards, these newer resin cements are related to present innovative initiators and co-initiators systems to improve the polymerization reaction.

Comparability between *in vitro* results is difficult because of differences in methodology. This study focused on the biomechanical behavior of different post lengths and adhesive strategies in critical restorations by applying fatigue loading before fracture test. This is important since fractures or clinical problems with restorations rarely occur under static and compressive loads only.[43] The number of cycles (1.200,000), the conditions of humidity (100%) and temperature (37ºC), the load angle and charge (160N) were chosen for the current study to better fit with clinical conditions based on previous reports.[3,22,44] Additionally, the periodontal ligament was also simulated, since it is believed that the use of a rigid material, such as only using an epoxy resin, to embed the teeth may lead to distorted load values and affect the mode of failure of the specimens.[21] In this study, an impression material was used to simulate the periodontal ligament.[21,29] In some recent studies which did not use this technique, higher values of fracture resistance, and also higher incidence of catastrophic failures even in cases with more conservative preparation/restoration, were found.[7,8] Ma et al. (2009)[45] stated that restored teeth with no ferrule did not survive as well as those with at least 0.5 mm of ferrule. However, those authors did not simulate the periodontal ligament, disabling comparability with this present results.

In this study, the incidence of catastrophic failures was low, which was similar to previous findings.[9] Interestingly, all the reparable fractures occurred in the composite resin crowns. In this sense, it can be speculated that increasing the resistance of the restorative material would increase the resistance of the restored tooth. As previously stated,[18] resin composites are not indicated for restoration of endodontically treated teeth without a ferrule. However, the primary intention of this study was to test the post effect. The composite resin used in the current study showed a good performance, since there were no fractures found after fatigue loading. The Vitra® composite (FGM Products) is characterized as a nanohybrid resin containing spheres of zirconia with an average size of 200 nm, in a total inorganic matric of 72-82% in weight (52-60% in volume). These data and the results of this study indicate that this material is effective for use in the restoration of extensively damaged teeth.

CONCLUSIONS

5 CONCLUSIONS

Within the limitations of this study, it can be concluded that:

- Shorter posts can be used to be more conservative, since no differences were found between the three post lengths tested;
- The adhesive strategy using an MDP-containing adhesive with a conventional cement showed better fracture resistance when compared to a self-adhesive cement.
- Some prospective studies should be performed intending to overcome the limitations of the *in vitro* studies and to evaluate the longevity of the results obtained with conventional cements using a MDP-based adhesive.

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