

INFLUENCE OF DIFFERENT ADHESIVE SYSTEMS ON BOND STRENGTH OF CARBON FIBER POSTS USED TO RESTORE ENDODONTICALLY TREATED TEETH

ABSTRACT

The aim of this study was to evaluate the influence of three adhesive systems on resinous bonding of carbon fiber posts on roots of endodontically treated bovine incisors. Thirty bovine lower incisors with similar dimensions were selected for this study. The roots were endodontically treated and subsequently prepared for post cementation. The posts were treated with adhesive systems Scotchbond MultiPurpose Plus – 3M chemical cure (Group I), light cure (Group II) and dual cure (Group III). Carbon fiber posts were adjusted to 8mm and cemented in the canal with resinous dual cement RelyX ARC – 3M. Those were taken to Universal Essay Machine for the push-out shear bond strength test. Analysis of the results were made with 2-Way ANOVA and post-hoc with Tukey's test ($p < 0.05$). The groups were statistically different. The chemical cure adhesive system (Group I) showed highest values of resistance to push-out, both at all thirds as well as in total average (24.77 MPa), followed by light cure adhesive (Group II, 22.26 MPa), and dual cure (Group III, 18.38 MPa). Scotchbond Multi-Purpose Plus – 3M adhesive system presented highest shear bond strength on resinous cementation of carbon posts to root dentin, and therefore is the first choice among the materials presented in this study.

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KEYWORDS

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INTRODUCTION

A great advance in materials and techniques has been occurring in Dentistry. However, restoration of endodontically treated teeth with great structural loss remains a challenge, and gives rise to discussion due to its fragility and susceptibility to fracture. Several studies are being conducted in an aim to determine the best material for intracanal post and core build, as well as the best adhesive technique among the systems available at the market.

Among fiber reinforce materials used for tooth reconstruction are carbon fiber posts, whose elasticity modulus is similar to that of dentin (18.6 GPa), of great importance for stress distribution along the root canal and thus longevity of those restorations.¹

In tooth reconstruction with carbon posts, the modulus of elasticity of the layer of cement has Strong influence on stress abortion ability. Carbon and glass fiber posts debonding does no cause damage to dental tissues. In addition, the carbon post is compatible to BisGMA molecules from the resin, thus being useful for the adhesive processes, and able to be cemented to the root canal with a resinous cement and adhesive systems. The cement-post-adhesive homogenous set distributes the stress along root structure and prevents fractures.²

Due to the similarity in elastic behavior of fiber posts and dentin, root fracture seldom

occurs in these restorations. On the other hand, adhesive failures usually happen through debonding of resinous adhesive cements. As resinous cements have shown better initial resistance than aqueous cements, they have been traditionally used on cementation of fiber posts. Previous studies have shown that bond strength between cement and post can be enhanced by reactivating the surface of the fiber post with chemical-mechanical treatments that turn those interfaces less susceptible to adhesive failure when compared to the relative unpredictability of cement-intracanal dentin.³

Therefore, it is necessary to evaluate the retention of fiber posts cemented with resinous cement and the possibilities of adhesive systems, in search of an enhanced interaction, union and resistance, and best referral of the material.

MATERIAL AND METHODS

Thirty bovine lower incisors, with similar anatomy, dimensions and root length between 16 to 20mm. The teeth were collected from slaughterhouses in Manaus-Am and kept in saline solution at room temperature during the study. The crowns were removed with diamond discs and root lengths adjusted to 16 mm.

The roots were endodontically treated using crowdown technique up to K File #35 at the working length. Throughout instrumentation, the canals were irrigated with sodium hypochlorite 2.5% and dried with absorbent paper points

(Tanari Tamariman Industrial LTDA, Manacapuru-AM). The canals were obturated using cold lateral obturation technique with gutta-percha point (Tanari Tamariman Industrial LTDA, Manacapuru-AM) and non-eugenol cement Sealer 26 (Dentsply Ind e Com. Petrópolis-RJ, Brasil).

The obturation material was removed from the canal except for the apical 5mm.⁴ Parallel, serrated carbon fiber posts with conical apex (Reforpost kit -Ângelus) constituted of 64% longitudinal carbon fibers and 38% epoxy resin matrix were selected. The post with 1.5mm cervical diameter and 1.1mm apical diameter (no. 3 from the kit) was used. Each kit comes with a set of burs corresponding to the diameter of the post, for a precise canal preparation.

After canal preparation, the specimens were randomly divided into three groups (n=10) and submitted to different adhesive processes, according to the manufacturer's recommendations, as follows:

Group I - Scotchbond Multi-Purpose Plus - 3M, chemical cure with 3 clinical steps.

Group II - Scotchbond Multi-Purpose Plus - 3M, light cure with 3 clinical steps.

Group III - Scotchbond Multi-Purpose Plus - 3M, dual cure, with 3 clinical steps.

Each specimen from each group was rinsed and paper cone dried after removal of obturation material with Largo burs. They were then etched with phosphoric acid 37% for 15s and rinsed with water for 15 s, and dried with paper points. The cement used for all groups was the dual cure cement RelyX ARC (3M Dental Products. St. Paul - USA).

The fiber posts were cleansed with alcohol 70%, followed by etching with phosphoric acid 37% for 15s, and the rinsed for another 15s. The adhesive Scotchbond Multi Purpose Plus - 3M was applied on the surface of the post, according to the group, following the manufacturer's instructions. The posts were finally cemented in the root canals with dual resinous cement.

The roots were kept in a moist environment for one week. The apical portion of each root was resected at 8mm height. Part of the post exceeding the cervical rim was also trimmed and discarded. The roots were then cut into 3 discs of 2 mm thick each and separated according to the region into cervical, medial and apical discs (Figure 1).

The discs were submitted to a push-out mechanical essay. They were positioned on a stainless steel base containing an central orifice of 2mm diameter. The disc-base set was place at the base of an Instron 4411 with 50Kgf load. A metallic rod with 1mm diameter active point was fixed at the machine and positioned at the center of the post.⁵ The push-out essay was carried up to total displacement of the post from the root canal (Figure 2).

The force necessary for displacing the post was recorded and converted do MPa, by dividing the force by the area of the root canal. The results were statistically analyzed with software SAS at 95% confidence.

At first, an exploratory analysis was conducted and the presence of one outlier was found. This value was removed from the results and the Analysis of Variance was conducted. The variables were Groups (I, II, III) versus Region (cervical, middle and apical). Tukey's test was used

for multiple comparisons between groups' averages.

Figure 1 - Samples before and after sectioning of discs.

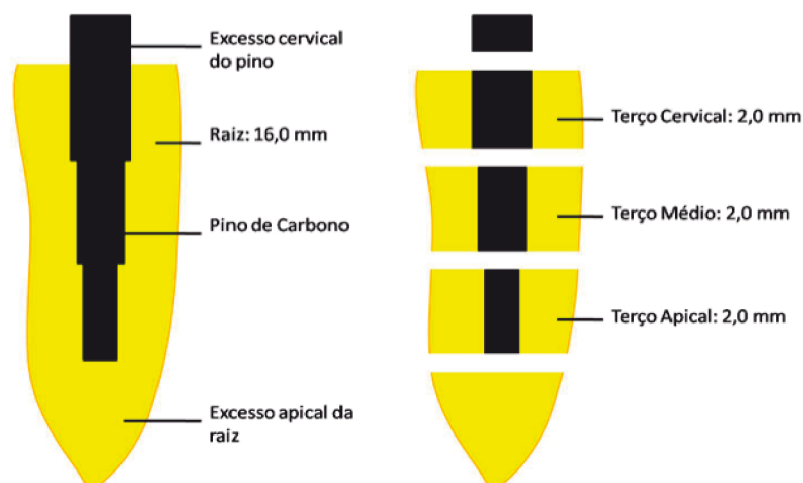
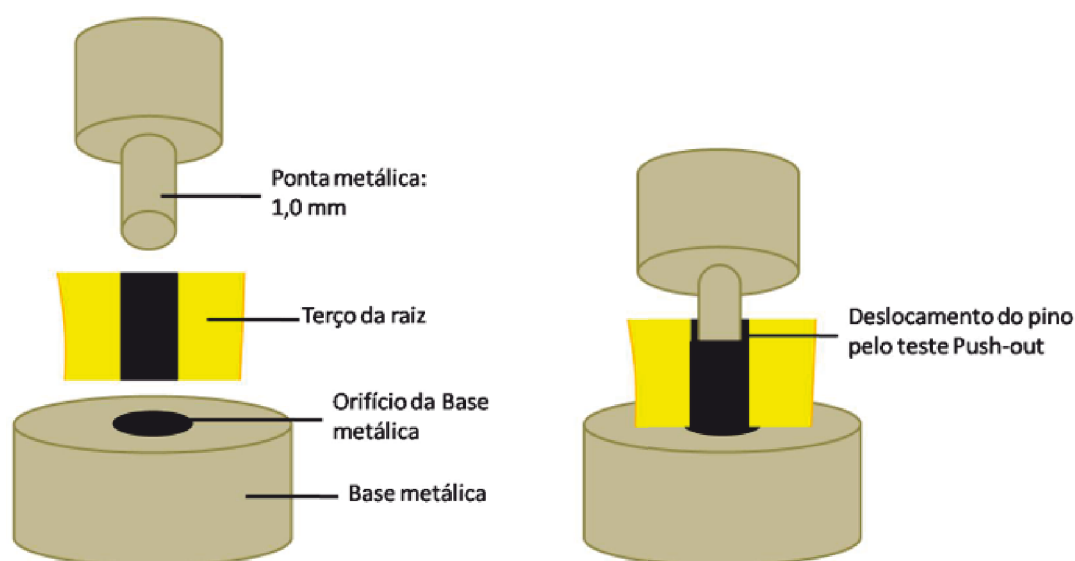


Figure 2 - Root disc in position at the universal essay machine. Post displacement.



RESULTS

Significant difference was found between groups ($p < 0.0001$) and between regions ($p < 0.0001$), but interaction of those factors was not significant ($p = 0.1339$).

DISCUSSION

Some bonding agents have the ability to adhere different types of restorative materials, including fiber posts, because they contain a monomer adhesive. Although fiber posts contain such adhesive, a common problem

with the material used for prefabricated fiber posts is that the polymer matrix between the fibers has many crosslinks and a high degree of non-reactive conversion, which makes very difficult to adhere fiber pin to composite resin cement and tooth structure.⁶ Because of the similarity of the elastic behavior between fiber

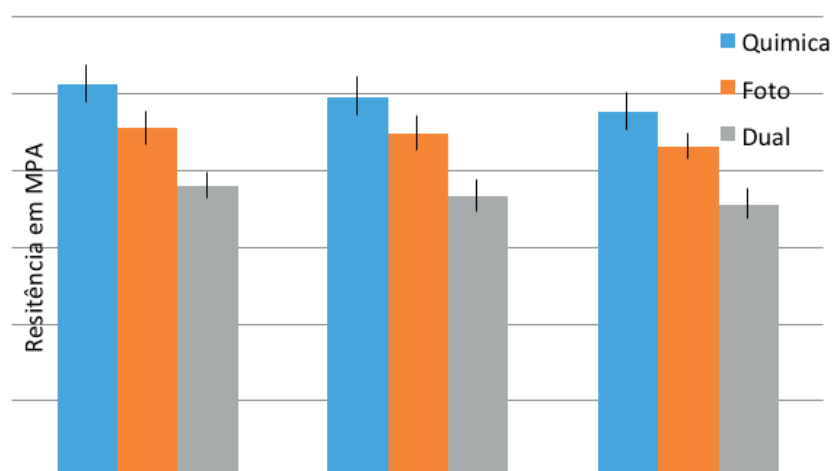
posts and root dentin, root fracture rarely occurs in these restorations. On the other hand, adhesive failures cause major concerns regarding this type of cementation, because they usually occur through the debonding of the union of resin cements.³

Table 1 - Mean (SD) of shear bond resistance (MPa).

Groups	Cervical	Medial	Apical
I (chemical cure)	25,6 (1,23) Aar	24,8 (1,24) Ba	23,8 (1,22) Ca
II (Light cure)	22,8 (1,05) Ab	22,4 (1,10) Bb	21,6 (0,82) Cb
III (Dual cure)	19,0 (0,82) Ac	18,3 (1,03) Bc	17,8 (0,96) Cc

Different letters represent significant difference ($p < 0.05$).

Graph 1 - Shear bond resistance (MPa).



Comparative studies between different bonding systems, cements and composites have shown the importance of obtaining a chemical compatibility of these materials, providing a post-adhesive-cement-adhesive-dentin more homogeneous and making them less susceptible to bonding failure. The clinical

success of a restoration of any kind is based mainly on sealing provided by the restorative material to the preparation margins. In case of restorations that combine composites and adhesive systems, good sealing is often restricted to the ability that material has to

resist the immediate mechanical stresses related to its type of polymerization.⁷

The formation of the hybrid layer is the main bonding mechanism of dental adhesive systems. Many studies compared the use of self-etching adhesive systems and conventional systems. Akgungor & Akkayan (2006)⁸ comparing the single-bottle adhesives, the primer system with self-conditioning and light-curing adhesive agent, it was noted that the specimens treated with self-etching primer showed similar bonding strength values in the cervical, middle and apical regions of the pin. Contradicting what usually happens in most cases the bond strength for these specimens were not correlated with the density of the tubules.

Arrais & Giannini (2002)⁹ conducted a comparative study between the conventional three-step adhesive (Scotchbond MP Plus) and self-etching system (Clearfil SE Bond). It was observed that the conventional adhesive system formed a deeper hybrid layer, because the depth of the demineralized dentin produced by phosphoric acid is greater than that produced by the self-etching primer, resulting in a thicker hybrid layer. Despite the self-etching primers having less acidity than phosphoric acid gel 35 %, they were still able to hold through the smear layer within the underlying mineralized dentin and form a hybridized complex; however, its penetration

into the dentin was less precise due to the presence of the smear layer, and thus formed a thinner hybrid layer.

Silva et al. (2005)¹⁰ also obtained similar results in their research, comparing Single Bond adhesive systems and self-etching. Cordeiro (2006)⁵ observed that specimens in which Single Bond was applied, the phosphoric acid promoted the total removal of the smear layer, exposing the network of collagen fibers that were later infiltrated by the adhesive, thus producing a well-defined dentin / resin zone of interdiffusion, with the presence of resin tags within dentinal tubules. On the other hand, with self-etching system, its low pH means it has a milder action on dentin, which may have led to lower values of union in the middle and apical root regions. However, Matos et al. (2001) concluded after comparing the self-etching adhesive, single component adhesive and conventional adhesive (acid + primer + bond), that the single component system showed higher tensile strength, differing from the results of most studies involving adhesives systems. Among the studies analyzed, it is observed that three-step conventional systems is the one with highest bonding values to root dentin, and therefore best resistance values.

With the adhesive system Scotchbond Multi -Purpose Plus – a three-step system – used in this study, etching was performed with phosphoric acid 37 %. According to the work

of Arrais & Giannini (2002)⁹, Cordeiro (2006)⁵ and Silva et al. (2005)¹⁰, etching promotes the removal of the smear layer, which justifies obtaining bonding values significantly higher after the push-out test in the three groups. However, statistically significant difference was observed that among the groups, with the highest value of resistance obtained in Group I (24.77 MPa), followed by Groups II (22.26 MPa) and III (18, 38 MPa). This may be mostly related to the type of polymerization of the adhesive and chemical compatibility between the adhesive system and cement.

In the present study, it was observed that Group I - chemical polymerization - showed the highest values of tensile strength when compared to Group II (light curing) and III (dual curing). One of the factors that may have led to these results is the fact that polymerization occurs independently of the presence of light, allowing a greater polymerization conversion and larger and more homogeneous strength throughout the length of the root canal. On light and dual curing systems, the curing light that reaches middle and apical thirds may not be sufficient to polymerize the adhesive completely. However this feature does not apply to chemical cure system (Group I), who despite having obtained highest bonding values on all three thirds, still showed a statistically significant difference among the three thirds of the same root canal. The retention of fiber

posts in root depends on the bond strength between the material of the post and resinous bonding agent as well as the bond strength between the resin bonding agent and space for the pin in dentin. Adhesive failures usually occur through debonding of resinous cements. As resin-based cements have been showing better initial forces than water-based cements, they have been traditionally used for the cementation of fiber posts. With light-cure materials, the polymerization stress generated due to adverse geometric configuration of the root canal can also intensify the detachment of resinous compounds of dentin wall and create interfacial cracks.^{3,8,12}

Nevertheless, it was observed that there were statistical differences between the different thirds of the same root canal. This was also related by Perdigão et al. (2006), who described that as the apical third is approached, there is a decrease in the density of tubules, and this represents that when different areas of the same root canal do not respond equally to etching, bonding ability to dentin may be different at different depths of the same root canal. They concluded that the coronal third presents a more reliable bond to the post than that of the middle or apical third. Thus, the prognosis of bonding is highest in the cervical level of the root. Such observations were confirmed in the present study, when it was observed that the values of bond strength decreased in the three groups according to the

depth of the root canal, with cervical third always higher than middle and apical thirds.

Factors that possibly interfere with the development of a high bond strength to root dentin is the non-uniform adaptation of bonding materials or their incomplete polymerization, both related to the difficult access to the root canal wall during handling. These factors may contribute to the low bond strength of adhesive cements found in the middle and apical root sections.¹² In our study, this statement can be relevant, as for all adhesive systems, the most apical portion of the root showed the lowest values of bond strength (23.76 MPa for group I, 21.58 MPa for group II and 17.82 MPa for group III). This is due to the fact that the humidity control, as well as the removal of excess adhesive with absorbent paper cones, and the insufficient reach of light in the most apical portion of the root, are critical, and are closely related to the low values of bond strength of adhesive systems in this third of the root. The curing light is placed nearer to the cervical portion of the root, and runs into apical direction. However, considering the length of the canal, it can be observed that the amount of light that will reach the apical portion is insufficient, and compromises both polymerization and bond strength of post and root dentin in this part of the root. The lower resistance values found in groups II and III can be related to insufficient light curing of these systems. In Group I, even

though bond strength values were higher than those of Groups II and III, a decrease in bond strength was found in apical third when compared to the middle and cervical thirds.

Souza et al. (2000)¹⁴ evaluated, *in vitro*, whether the use of zinc oxide eugenol cement exerted influence on microhardness of restorations of composite resin (Z100) performed with two adhesive systems, one that removes the smear layer (Scotchbond Multi-Purpose Plus - 3M) and another that promotes the treatment of smear layer without removing it completely (Clearfil Liner Bond 2). For each adhesive there was a control group (without zinc oxide eugenol) and another group in which they did and then removed the temporary restorations with zinc oxide eugenol cement. No statistically significant difference in the microhardness of composite resin was found between groups. Because eugenol is reported as an inhibitor of polymerization of resin cements (Souza et al., 2000), in our study it was used for endodontic obturation cement Sealer 26, which does not contain eugenol, in an attempt to avoid any alteration on adhesive and cementation processes, and inconsistent results.

CONCLUSION

Chemical cure Scotchbond Multi-Purpose Plus adhesive system showed highest shear bond resistance on resinous cementation of carbon fiber

posts to root dentine, and is the first choice material amongst the materials tested on this work.

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