

Influence of adhesive system on quartz fiber post dislocation resistance in endodontically treated teeth

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Abstract

Aim: To evaluate the dislocation resistance of the quartz fiber post/cement/dentin interface after different adhesion strategies. **Methods:** Forty bovine lower central incisors were selected and prepared with K-files using the step-back technique, and irrigated with 3 mL of distilled water preceding the use of each instrument. Prepared teeth were stored at 37°C and 100% humidity for 7 days. The roots were prepared and randomized into 4 groups. The quartz fiber post was cemented with an adhesion strategy according to the following groups: G_{BisCem} - BISCEM; $G_{\text{OneStep}\pm\text{C}\&\text{B}}$ - One Step \pm C&B; $G_{\text{AllBond}\pm\text{C}\&\text{B}}$ - AllBond3 \pm C&B; $G_{\text{AllBondSE}\pm\text{C}\&\text{B}}$ - AllBondSE \pm C&B with a quartz fiber post. Cross-sectional root slices of 0.7 mm were produced and stored for 24 h at 37° C before being submitted to push-out bond strength. **Results:** The mean and standard deviation values of dislocation resistance were G_{BisCem} : 1.12 (\pm 0.23) MPa, $G_{\text{OneStep}\pm\text{C}\&\text{B}}$: 0.81 (\pm 0.31) MPa, $G_{\text{AllBond}\pm\text{C}\&\text{B}}$: 0.98 (\pm 0.14) MPa, and $G_{\text{AllBondSE}\pm\text{C}\&\text{B}}$: 1.57 (\pm 0.04) MPa. $G_{\text{AllBondSE}\pm\text{C}\&\text{B}}$ showed significantly higher values of dislocation resistance than the other groups. **Conclusions:** Based on this study design, it may be concluded that adhesion strategies showed different results of quartz post dislocation resistance. Simplified adhesive system with sodium benzene sulphinate incorporation provided superior dislocation resistance.

Keywords: Tooth, Endodontically-Treated. Post and Core Technique. Resin Cements. Dentin-Bonding Agents.

Introduction

The objectives of the restorative treatment of endodontically treated teeth with large crown destruction are giving the teeth more resistance to masticatory forces, reestablishing function, and esthetics¹. Thus, sometimes the use of intraradicular post and cores is necessary^{2,3}. Ideally, the intraradicular post and cores should not move into the root canal and forces are distributed in the teeth homogeneously, decreasing the risk of tooth fractures^{4,5}.

Cast metal posts have been used for a long time in clinical practice and have presented high survival rates⁶. Metal posts have high elastic modulus, which increases fracture and catastrophic root failure. Therefore, glass fiber posts have been introduced as an alternative. Due to their low elastic modulus compared with cast metal posts, glass fiber posts have decreased the number of catastrophic failures⁷. In addition, they are more aesthetic and result in less clinical time^{3,8,9}.

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Carbon-fiber posts were introduced in the 1990s, and after that other types were produced such as glass fiber posts and zirconia and quartz posts. Fiber posts are cemented with a polymer luting cement to dentin due to chemistry affinity for its own epoxy resin matrix with the resin cement and quartz posts presenting a 98% survival rate after 9 years⁹. However, difficulty in adhesive cementation is observed and debonding is the main type of failure¹⁰⁻¹⁵. It is important to know which adhesive strategy should be used to decide the best choice for fiber post cementation¹⁶. Thus, the objective of this study was to evaluate the dislocation resistance of the quartz fiber post/cement/dentin interface after different adhesion strategies. The null hypothesis was that the different adhesion strategies would not affect the dislocation resistance.

Material and methods

Teeth preparation

Forty bovine incisors were selected for this study. To be included, the following criteria had to be met: straight roots and a root length of at least 15 mm. External debris were removed with a periodontal curette and scalpel blade. The teeth were sectioned transversely 15 mm from the apex using a slow-speed diamond disc under water coolant, the pulp tissue was removed, and chemo-mechanical preparation was performed according described previously^{17,18}. The root canals were prepared with K-files using the step-back technique and irrigated with 3 mL of distilled water preceding the use of each instrument. After that, they were stored at 37°C and 100% humidity for 7 days. Subsequently, the roots were prepared (Figure 1) with a specific Bisco burr (BISCO Int., Schaumburg, Illinois, USA), and randomized into 4 groups. Quartz fiber post was cemented according to the adhesive system and cements (Table 1). Fiber posts had 12 mm of length, 1.8 mm of cervical diameter and 1.0 mm of apical diameter.

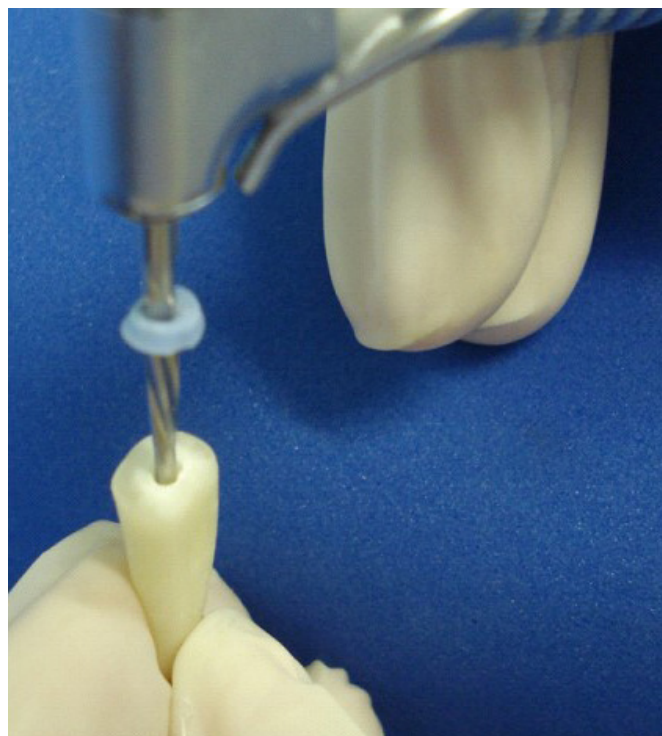


Fig.1. Roots prepared with specific bur.

Table 1 - Groups, materials and methods used in the study.

Group	Material	Method
G _{BisCem}	BisCem Cement (BISCO)	Mixed for 15 s, applied to the post and root canal; photoactivated for 30 s.
G _{OneStepsC&B}	Phosphoric acid 35% (Coltene/Whaledent, Cuyahoga Falls, Ohio, USA)	Applied for 15 s; rinsed with distilled water; dried with absorbent paper cones.
	One Step (BISCO)	Applied for 20 s; dried with absorbent paper cones; photoactivated for 20 s.
	C&B Cement (BISCO)	Mixed for 15 s; applied in the post and root canal.
G _{AllBond±C&B}	Phosphoric acid 35% (Coltene/Whaledent)	Applied for 15 s; rinsed with distilled water; dried with absorbent paper cones.
	All Bond 3 A & B (BISCO)	Mixed primer A and B for 5s; applied for 20 s; dried with absorbent paper cones; applied adhesive resin and photoactivated for 20 s.
	C&B Cement (BISCO)	Mixed for 15 s; applied in the post and root canal.
G _{AllBondSE±C&B}	Phosphoric acid 35% (Coltene/ Whaledent)	Applied for 15 s; rinsed with distilled water; dried with absorbent paper cones.
	All Bond SE I and II (BISCO)	Mixed part I and part II for 5 s; applied for 20 s dried with absorbent paper cones; photoactivated for 20 s;
	C&B Cement (BISCO)	Mixed for 15 s; applied in the post and root canal.

Push-out test

After cementation of the quartz post, the teeth were sectioned transversely into 7 slices that were approximately 0.7 mm thick using a low-speed disc (Isomet, Buehler Ltd, Lake Bluff, IL, USA) with constant water cooling. The internal diameter of the canal of each slice was measured with a digital caliper (Digimess, 100.174BL, Digimess Instrumentos de Precisão Ltda, São Paulo, SP, Brazil) and the contact area between the filling and dentin of each slice was calculated. Each slice was placed with the apical side up on a mechanical testing machine (DL-2000, EMIC Equipamentos e Sistemas de Ensaio Ltda, São José dos Pinhais, PR, Brazil). A force was applied to the shutter toward the apical neck using a 500 N load cell and a crosshead speed of 1 mm/min with a 0.8-mm diameter cylindrical device. The dislocation resistance (MPa) was obtained by dividing the force (N) required to displace the filling material by the adhesive area (mm²). The adhesive area was calculated using (1 and 2):

$$g = (h^2 \pm (R2 - R1)^2)^{1/2} \quad (1)$$

$$A = \pi.g.(R1 \pm R2) \quad (2)$$

where, g is the root taper, R1 represents the apical radius, R2 represents the coronal radius, h is the thickness of the slice, and A is the adhesive area.

Apical and coronal radii were obtained from photographs and measured with Image Tool software 10 times from different sides to obtain the radii means (Figure 2).

Statistical Analysis

Data normality was checked by the Kolmogorov-Smirnov test. Data were analyzed by ANOVA and the Tukey post-hoc test. A significance level of 5% was used for analysis.

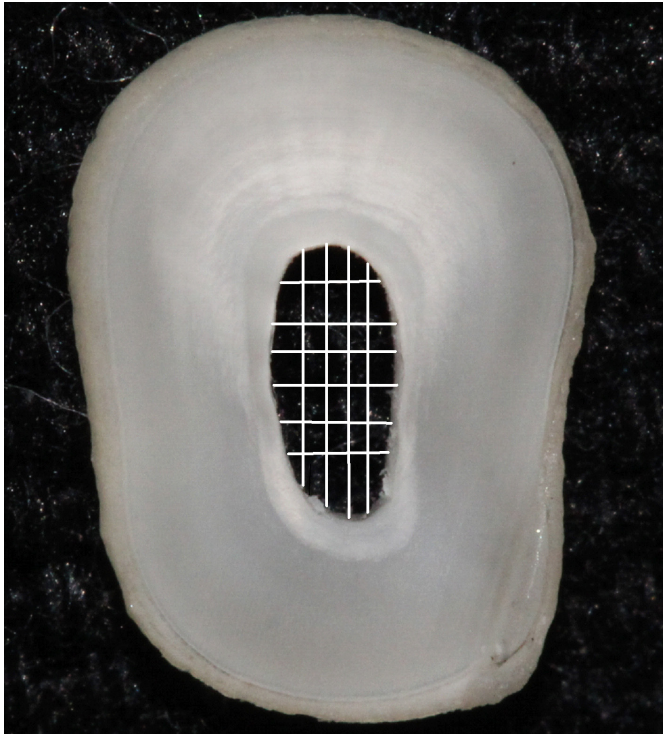


Fig.2. Photograph of canal slice and measurement of internal diameter with software in 10 different regions.

Results

The results of the dislocation resistance are shown in Table 2 and Figure 3. The $G_{AllBondSE \pm C \& B}$ group presented the highest dislocation resistance value (1.57 ± 0.04 MPa), with a significant difference from the other groups, $p < 0.05$. G_{BisCem} (1.12 ± 0.23 MPa), $G_{OneStep \pm C \& B}$ (0.81 ± 0.31 MPa), and $G_{AllBond \pm C \& B}$ (0.98 ± 0.14 MPa) did not show statistically significant differences between each other, $p > 0.05$.

Discussion

In this study, the dislocation resistance of root dentin/cement/post was evaluated after different adhesive strategies. The materials in this study showed easy clinical use, furthermore, the decreased catastrophic failure could have occurred as result of correct dissipation of forces in the middle third of teeth. The use of fiber post with resin cement leads to a block formation with dental tissue since the elastic modulus is similar to dentin (18 GPa), once the values for fiber post is between 16-40 GPa and resin cement between 6.8-10.8 GPa¹⁹. However, the adhesive system strategies used in this study showed different results for dislocation resistance, and the highest values were found in the $G_{AllBondSE \pm C \& B}$ group.

Difficulty in hybrid layer formation results in ineffective adhesion and a decrease in dislocation resistance due to: high factor cavity configuration, high polymerization shrinkage, and difficulty in the homogeneous acid condition of the root walls⁸. In the G_{BisCem} group, self-adhesive cement was used. This cement compounds the acid monomers, which demineralize the dentin substrate while

infiltrating the monomers to form a hybrid layer. It is likely that the lower dislocation resistance occurred due to the fact that there was no formation of a homogeneous hybrid layer¹⁴.

Table 2 - Results of mean and standard deviation, in MPa, of dislocation resistance (DR) with different adhesive cements.

Groups	DR (MPa)
G_{BisCem}	1.12 (\pm 0.23) B*
$G_{OneStep \pm C \& B}$	0.81 (\pm 0.31) B
$G_{AllBond \pm C \& B}$	0.98 (\pm 0.14) B
$G_{AllBondSE \pm C \& B}$	1.57 (\pm 0.04) A

*Different capital letters indicates statistically significant difference within the column ($p < 0.05$).

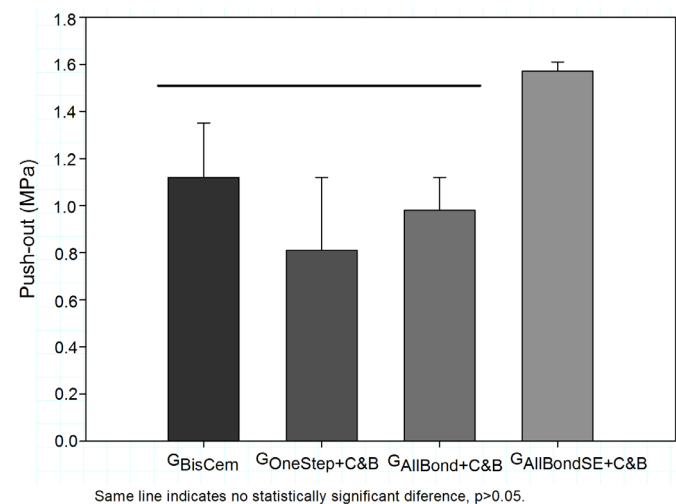


Fig.3. Push-out (MPa) values of groups tested (G_{BisCem} , $G_{OneStep \pm C \& B}$, $G_{AllBond \pm C \& B}$ and $G_{AllBondSE \pm C \& B}$).

The simplified adhesive systems (primer with adhesive) showed statistically significant lower dislocation resistances between groups ($G_{OneStep \pm C \& B}$ and $G_{AllBondSE \pm C \& B}$), $p < 0.05\%$. One Step adhesive is a universal self-adhesive of one plot that presents hydrophilic monomers (hydroxyethyl methacrylate), acid monomers, and acetone as solvent. Hydroxyethyl methacrylate presents low hydrolytic stability when in the same environment with acid monomers and degrades in little time. Furthermore, acetone solvents have high volatility, which makes the operator technique difficult and justifies the low value of dislocation resistance²⁰. However, in this study, a significant difference between the $G_{OneStep \pm C \& B}$ (universal adhesive), $0.81 (\pm 0.31)$, and $G_{AllBond \pm C \& B}$ (etch-and-rinse adhesive), $0.98 (\pm 0.14)$, groups was not observed, $p > 0.05\%$. Conventional adhesive systems, with 3 steps etch-and-rinse, present difficulties related to incomplete acid filling of the root and incorrect evaporation of the primer solvent, compromising the adhesion process, mainly in the medium and apical thirds^{13,14,21,22}.

The highest values of dislocation resistance were found in the $G_{AllBondSE \pm C \& B}$ group. It is likely that the compound present in part I of the adhesive, sodium benzene sulphinate, acts as a co-

initiator in the acid-base reaction between benzoyl peroxide and tertiary amine of the chemically cured resin cements, increasing the results of dislocation resistance²³⁻²⁵. The sodium benzene sulphinate allows the acidity of the adhesive system to demineralize the dentin substrate without interfering in the resin cement degree of conversion. Thus, it is possible that the incorporation of the co-initiator avoids the chemical incompatibility between simplified adhesives and chemically cured resin cements.

Based on this study design, it is licit to conclude that the adhesion strategies showed different results of quartz post dislocation resistance. The simplified adhesive system with sodium benzene sulphinate incorporation presented superior dislocation resistance.

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