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Original Research Article

Bond strength of dual-cured resin cements to root canal dentin

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Abstract

Introduction: The bonding of dental posts to the root canal walls depends on the resin cement. **Objective:** This *in vitro* study assessed the bond strength of resin cements used for post cementation to different root regions. **Material and methods:** Thirty canine roots were endodontically treated and prepared to receive dental posts which were luted with different resin cements (n = 10): Enforce (Dentsply), Panavia F (Kuraray Dental Co) and RelyX ARC (3M ESPE). The cements were light-cured for 20 s. After cementation, slices from cervical, middle and apical post/root regions were submitted to the push out test in a universal testing machine. The data (MPa) were analyzed using ANOVA and Tukey's test ($\alpha = 0.05$). **Results:** RelyX ARC (3.24 ± 1.49) and Enforce (3.45 ± 1.42) showed higher bond strength than Panavia (0.95 ± 0.39) ($p < 0.05$), without statistically significant difference between each other ($p > 0.05$). The bond strength values at the cervical (3.37 ± 1.47) were higher than middle (2.62 ± 1.94) and apical (1.65 ± 0.99) regions ($p < 0.05$), which were similar between them ($p > 0.05$). **Conclusion:** The resin cements RelyX ARC and Enforce presented greater bond strength than Panavia and the bond strength was higher at the cervical region.

Introduction

Intraradicular post and cores are an option for restoring endodontically treated teeth presenting excessive crown destruction [2], because they favor the stability and retention of direct and indirect restorations [16].

Glass fiber reinforced composite resin posts have been extensively used because of their good aesthetics, elasticity modulus similar to that of natural teeth and other biomechanical properties similar to tooth structure [24].

The holding of these posts is executed through bonding to root dentin by using adhesive systems and resin cements [13]. According to their curing, the resin cements are divided into those chemically activated (self-cured), those physically activated by light (light-cured) and those presenting both activation systems (dual-cured).

Dual-cured resin cements were developed in an attempt to combine the desirable properties of both chemical and light activation [21]. Immediate photo-activation assures the initial stability necessary for supporting the masticatory tensions while chemical activation assures the reaching of the maximum properties of the cement as time goes by [8]. Although initiated independently, both mechanisms of curing start a dynamic formation of free radicals and conversion of monomers which naturally are overlapped during the curing phase [21, 23]. Inside root canals, the light power could not be enough to cure the resin cement, mainly at apical area. In these cases, the chemical activation of dual-cured cements may compensate the difficult of curing by the light [21]. The proper curing of resin cements may influence on the mechanical properties of the agents and on the bonding of the resin cements to tooth substrates [7, 11].

Different resin cements with their respective adhesive systems may be used for the cementation of the posts. Such materials have different composition, amount and size of filler particles [5, 9], as well as characteristics and protocol of cementation which in addition to the cement curing may interfere in the bonding to tooth surface [3, 6].

Therefore, the aim of this study was to evaluate *in vitro* the bond strength of dual-cured resin cements to root dentin, at different deeps, employed in the cementation of intraradicular posts through push out test.

Material and methods

Study design

The study's factors were *resin cement* – Enforce (Dentsply Ind. e Comércio Ltda., Petrópolis, RJ, Brazil), Panavia F 2.0 (Kuraray Dental Co., Okayama, Japan) and RelyX ARC (3M ESPE, Dental Products, St. Paul, MN, USA) –, and *post/root canal area*: cervical, medium, apical. The study sample was composed of 30 human permanent canine teeth (n = 10). The response variable was the analysis of the bond strength through push out test.

Sample selection

Human maxillary permanent canine teeth, kept in 0.1% thymol solution at 9°C, were washed in tap water for 24 h to eliminate the thymol solution remnants and next macroscopically examined and radiographed at mesial-distal direction to standardize the sample. Thirty teeth with completely formed roots, with a single canal without calcifications, presenting marked curvatures were selected.

Endodontic treatment

The teeth were cross-sectioned at their long axes, next to the enamel-cement junction, with the aid of a double-face diamond disc (KG Soresen, Barueri, SP, Brazil) at low speed (Dabi Atlante Ltda., Ribeirão Preto, SP, Brazil), aiming to standardize the length of the roots in 19 mm. The working length was established at 1 mm short of the measurement obtained after the insertion of a size #15 K instrument (Maillefer, Ballaigues, Switzerland) within root canal up to its tip was visualized in the apical foramen.

The biomechanical preparation of root canals was initiated by the preparation of the cervical third through using a size #20 rotary instrument (LA Axxes D1, yellow, SybronEndo, Orange, CA, USA). Next, the canals were submitted to sequential instrumentation with Hero 642 rotary system (Micro-Mega, Besançon, France), driven by a contra-angle handpiece (Anthogyr S.A., France) with continue rotary movement.

During biomechanical preparation, root canal irrigation was performed with 1% sodium hypochlorite, at every instrument change, and final irrigation with EDTA for 3 minutes, followed by irrigation with distilled water. Root canals were filled with the main gutta-percha point (Dentsply-Maillefer, Petrópolis, RJ, Brazil), accessory points (XF, Dentsply-Maillefer, Petrópolis, RJ, Brazil) and cement (AH Plus, Dentsply DeTrey, Konstanz, Germany). The points were cut with a heated instrument and condensed; the cement excess was removed and the roots were restored with a provisional material (Cavit, Premier, Norristown, PA, USA). Next, the roots were kept at 37°C for 48 h.

Intraradicular post cementation

Prior to the post cementation, the provisional material was removed and the canal underwent partial desobturation (12 mm), leaving 6 mm of the apical filling material, with the aid of specific instruments provided by the manufacturer of Reforpost fiber post (Angelus, Londrina, PR, Brazil).

A layer of silane (Bis-Silane; Bisco Inc, Schaumburg, IL, USA) was applied onto the posts with the aid of a brush, and after 60 s, a gentle air jet was applied.

The roots were randomly divided into three groups (n = 10), according to the resin cement to be used for the cementation of the glass fiber posts: I) Panavia F (Kuraray); II) Enforce (Dentsply); III) RelyX ARC (3M ESPE).

For the groups luted with RelyX and Enforce, root canals were etched by 37% phosphoric acid for 15 s, followed by washing for 30 s and drying through absorbent paper points. Following, an adhesive system was applied (Adper Single Bond, 3M ESPE Dental Products, St Paul, MN, USA) onto the root dentin and light-cured for 20 s by using a LED light-cure unit (1500 mw/cm^2, Radii Plus, SDI Ltda., Bayswater, Victoria, Australia). This same adhesive system was also applied onto the post surface and light-cured for 20 s. For the group luted with Panavia, the adhesive system (ED Primer II; Kuraray, Tokyo, Japan) was applied inside root canal and onto the post surface for 30 s, followed by the application of gentle air jets and light-cured for 20 s.

The resin cements were handled according to the manufacturer's instructions, and taken inside root canal with the aid of a periodontal probe and applied onto the surface of the posts with a brush. The posts were immediately inserted inside root canals, kept under pressure, and the excess of the cement was removed. The specimens were light-cured by using a LED light-cure unit (Radii Plus, SDI) placed on the cervical area of the post for 40 s, at labial and palatal surfaces, totalizing 80 s. The specimens were kept in artificial saliva at 37°C for 24 h.

Evaluation of bond strength of the resin cement to dentin

The roots were sectioned in a cutting machine (Isomet 1000 Buehler, Hong Kong, China), under refrigeration, to obtain three *slices* of about 1.0 mm of thickness, corresponding to each post/root canal area.

The push out test was executed in a universal testing machine (Instron 4444, Instron Corporation, Canton, MA, USA) at crosshead speed of 0.5 mm/min. A stainless steel device was used to place the samples aligned to the bar employed to perform the test. The bar's tip presented 6 mm of diameter and 4 mm of length. Data were obtained in Newtons (N) and transformed into megapascal (MPa), dividing them by the area (mm^2) of the post/dentin interface.

To analyze the resin cement/dentinal wall interface after the bond strength test (*push out*) and to define the fracture pattern, the samples were analysed with the aid of a stereoscopic magnifying lens (Leica microsytem LTD, Wetzlar, Germany) at x40 magnification and classified regarding to the fracture pattern as: adhesive (when the root canal walls were completely free of cement); cohesive (when the cement completely covered the root canal walls); and mixed (when it was observed dentin areas either free or covered by resin cement).

Statistical analysis

For statistical analysis, the force necessary for the displacement of the resin cement was transformed into tension, in megapascal (MPa). After the assessment of the sampling homogeneity (Kolmogorov-Smirnov test), two-way ANOVA was applied. Tukey's test was used in the cases that ANOVA showed statistically significant differences. The tests were executed with the aid of SPSS 17 software (SPSS Inc., Ill, EUA), with level of significance of 5%.

Results

Two-way ANOVA demonstrated a statistically significant difference for the factors *resin cement* ($p = 0.000$) and *post/root canal area* ($p = 0.000$), without difference for the interaction of factors ($p = 0.084$).

Panavia (0.95 ± 0.39) provided the smallest bond strength values with statistically significant differences compared with RelyX ARC (3.24 ± 1.49) and Enforce (3.45 ± 1.42), which were statistically similar between each other ($p > 0.05$).

Concerning to the post/root canal area, the cervical third (3.37 ± 1.47) showed a higher bond strength than medium (2.62 ± 1.94) and apical (1.65 ± 0.99) thirds ($p < 0.05$), which were statistically similar between each other ($p > 0.05$).

The failures analysis demonstrated that for RelyX ARC there was the predominance of cohesive failures at the cervical third and adhesive failures at the medium and apical thirds. For Panavia, there was a greater percentage of adhesive failures at the cervical and medium thirds and mixed failures at apical third. For Enforce, failures were predominantly adhesive, regardless of the post/canal root third.

Discussion

The holding of intraradicular posts is performed through bonding to root dentin by using adhesive systems and resin cements [13]. The success of these procedures depends among other factors on the resin cement and their properties [3]. In this sense, the characteristics inherent to the material and the difficulty in light-curing [4, 7, 20] may harm the clinical performance, resulting in the technique failures due to bonding failure to tooth substrate. The loss of bonding at the post/cement/root dentin interface is considered the main failure reason of these procedures [10, 18].

To evaluate the bonding of fiber posts to root canal and the efficacy of either the luting material or luting technique, the push out test has been considered as a valid method [18]. This test is based on the bond strength between the dentin and cement as well as between the post and cement [12]. In this present study, the push out test was performed 24 h after cementation, because bond strength may increase in this period [13].

The results of this present study demonstrated that the bond strength of Panavia was smaller than that of RelyX ARC and Enforce, corroborating the findings of Faria-e-Silva *et al.* [7]. A possible explication could be the composition differences (filler amount) among the cements [7]. According to the manufacturer's instructions, the filler amount of Panavia is higher than that of RelyX ARC and Enforce. Such characteristic is associated with the development of a greater polymerization stress [14]. This fact may account for adhesive failures at the cement/dentin interface, which were observed in the analysis of the failure pattern, and would explain the smaller bond strength of Panavia found by this study.

The penetration capacity of resin cements is of great importance for bond strength [7]. Thus, it is supposed that Panavia, because of its high viscosity, probably showed a low penetration in the micro retentions, resulting in low bond strength [7]. RelyX ARC has shown low viscosity, which could contribute for its best penetration into the surface [17] and bonding.

This present study followed the manufacturer's instructions of the resin cements. The manufacturer of Panavia indicates the use of a self-etching adhesive system, which modifies but it does not remove the smear layer [19]. The lack of etching in the luting protocol of Panavia may also compromise the bond strength of this cement. The effect of etching with phosphoric acid is the surface demineralization with the dissolution of the peritubular dentin, exposition of the collagen fiber net of the intertubular dentin and opening of dentinal tubules [26], which facilitates the penetration of the bonding agent and contributes for the material bonding.

Concerning to the post/root canal regions, the bond strength at cervical third was higher than that of the medium and apical thirds. Such fact is because of the light difficult in reaching the most deep regions of root canal [15]. Studies reported that dual-cured luting agents are dependent on light-curing to reach the proper degree of conversion, favorable mechanical properties and satisfactory clinical performance [4, 7, 8, 20].

Other aspect which may contribute for the lowest bond strength at the medium and apical regions is the presence of residual gutta-percha and incomplete hybridization of the denim, which may result in lack of sealing in dentin/cement interface at the most apical regions [22]. It is speculated that the visualization and access of both instruments and etching and bonding agents are favored at the cervical third and contribute for the best bond strength values at this region [25].

This present study encourages further studies on the evaluation of other parameters, such as the post type, other cements and adhesive systems regarding to their influence on bonding to dentin.

Conclusion

Based on the methodology employed and on the results of this present study, it can be concluded that RelyX ARC and Enforce showed a higher bond strength than Panavia; also, the bond strength at the cervical region was higher than that at medium and apical regions.

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