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ORIGINAL RESEARCH

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The Interference of the Cleaning Procedure of Root Walls with Two Different Solvents on the Adhesion of Fiberglass Intraradicular Posts

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ABSTRACT

Aim: This study was undertaken to examine the effect of root canal (RT) sealers content and the cleaning procedure of RT walls on bond strength (BS) of a fiber reinforced composite (FRC) post cemented with resin-based or zinc phosphate cement.

Materials and methods: Forty bovine roots were divided into 2 groups (n = 20) and obturated with gutta-percha points plus Sealer 26 sealer or gutta-percha points plus N-Rickert sealer. In each group, half (n = 10) of intracanal walls was cleaned with ethanol and the other half with sulfuric ether. In each of these subgroups, half of intracanal posts (n = 5) were cemented with Bistite resin-based cement and half with zinc phosphate cement. Specimens were submitted to pull-out test and tensile force until post dislodgement. The maximum forces required for post removal was expressed in MPa, means were submitted to statistical analysis (Analysis of Variance Test, $\alpha = 0.05$).

Results: Fiber reinforced composite cemented with zinc phosphate were significantly more retentive than those cemented with Bistite ($p < 0.05$). Regarding the influence of eugenol-based sealer on post retention, there was a statistically significant difference ($p < 0.05$) only between groups cemented with Bistite, in which canals filled with N-Rickert + gutta-percha showed lower BS than canals filled with Sealer 26 + gutta-percha.

Conclusion: Despite endodontic cement used, higher pull-out bond strength were obtained when posts were cemented with zinc phosphate.

Clinical significance: The importance of ethanol or sulphuric ether application to properly replace water from intraradicular dentine still requires further investigations, especially to clarify if this technique may reduce the effect of aging and improve the stability of the bond, when used to cement fiber posts into the root canal.

Keywords: Laboratory research, Dentin, Eugenol, Resin cements, Root canal filling material, Pull-out test, Cleaning procedure.

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INTRODUCTION

The use of cast posts and cores to retain the prosthetic crown is a universal clinical procedure. Posts are widely used for restoring endodontically treated teeth. When a pulpless tooth presents insufficient structure, it's necessary to build a post-and-core structure to retain the prosthetic crown. However, cast posts present some disadvantages, such as longer operative time, involvement of laboratory procedures and removal of healthy tooth structure.

The greatest advantage when using prefabricated post and core procedures relies on minimally invasive dentistry, as prefabricated post systems can adequately adjust to prepared RT without removing health remaining tooth structure. Besides that, prefabricated post systems became popular because they can provide satisfactory results, while saving time and reducing costs.[1]

Growing demand for esthetic restorations have led to the development of tooth-colored, metal-free dowel and core systems. Posts made of glass fibers or zirconia ceramics became popular because they increase light transmission within the root. In addition, posts should have an elastic modulus similar to dentin in order to effectively transmit stress, evenly distribute occlusal forces along the root, reduce stress concentration and increase fracture resistance.[2]

Biomechanical properties of FRC, which are composed of glass fibers, inorganic filler and a resin matrix, have been reported to be similar to dentin,[3] and the low modulus of elasticity has been reported to reduce root fracture risk.[4] If endodontic retreatment is required, metal posts are considerably more difficult to remove[5,6] than FRC.

Fiber reinforced composite posts can be used with several luting cements. However, the highest bond strength values are presented for resin-based luting cements, since adhesive technique form a stable and reliable union with dentin. However, it is known that eugenol-containing root-canal sealers inhibit polymerization of resin-based luting agents.[6-9]

Manufacturer's instructions suggest removing contaminants of the tooth surface by brushing with pumice or ultrasonic scaling. Further, clean tooth surface with ethanol, citric acid, EDTA or phosphoric acid to improve adhesion and to remove any of the following: Temporary cement residue, oil from materials to test crown fit, oil mist from handpiece, saliva, blood and/or exudates fluids. On the other hand, authors[10] reported that gutta-percha solvents have an adverse effect on bond strengths of adhesive cements to RT dentin.

The purpose of this *in vitro* study was to examine the effect of eugenol-and noneugenol-containing RT sealers and the cleaning procedure of root walls with two different solvents on the adhesion of intraradicular posts cemented with resin-based cement or zinc phosphate cement.

MATERIALS AND METHODS

Sample Preparation

Forty recently extracted single-rooted bovine incisors were selected according to shape and length of straight roots (at least 15 mm long), with no pronounced flatness (mesiodistal or buccolingual).

Teeth were cleaned and stored for no more than 30 days in distilled water at 4ºC until use. The crowns were sectioned transversally 1 mm coronal to the cementoenamel junction and discarded. The roots were embedded in acrylic resin (Artigo Odontológico Jet-Clássico, SP, Brazil) using circular plastic molds and kept in a hermetic sealed container with distilled water.

Pulp tissue was removed and RTs were instrumented to a working length of 14 mm (1 mm short of the apex) up to a #50 K-file (Dentsply/Maillefer, Ballaigues, Switzerland) according to the crown-down technique. During instrumentation, canals were irrigated with 2 ml 0.5% sodium hypochlorite, alternately with Endo-PTC (Biodinamica Ltda, PR, Brazil), at every file change. The roots were dried with paper points (Dentsply Ltda, RJ, Brazil) and sealed.

Specimens were randomly assigned to 2 groups (n = 20), according to root sealer: An eugenol-based sealer (N-Rickert cement-Biodinamica Ltda, PR, Brazil) or a non-eugenol based cement (Sealer 26-Dentsply Ltda, RJ, Brazil) which was introduced into canals using a lentulo spiral instrument (Dentsply/Maillefer, Ballaigues, Switzerland).

Master ISO size-50 gutta-percha cones (Dentsply Ltda, RJ, Brazil) were coated with the chosen sealer and placed into canals until working length. Lateral condensation with a finger spreader (Dentsply Ltda, RJ, Brazil) and fine accessory gutta-percha points (Dentsply Ltda, RJ, Brazil) was performed until canals were fully obturated.

Coronal RT openings of all roots were sealed with a temporary material (Coltosol; Vigodent, Rio de Janeiro, RJ, Brazil) for 72 h at 37ºC in a humidor (100% relative humidity) until cement hardening.

Post Space Preparation

After storage, preparation and cementation of the posts were performed following established procedures. The gutta-percha was removed with Gates-Glidden drills (Dentsply/Maillefer, Ballaigues, Switzerland), leaving behind at least 5 mm of intact gutta-percha. A new instrument was used for every 5 specimens. Standardized 7 mm long post space was prepared with a size #3 standard Largo drill (Dentsply/Maillefer, Ballaigues, Switzerland).

Post spaces were cleaned with an anionic detergent solution (Tergensol, Inodon, Porto Alegre, RS, Brazil) and water, and dried with paper points (Dentsply Ltda, RJ, Brazil). After that, post spaces were cleaned with two different solutions, ethyl alcohol (92, 8º INPM) or sulphuric ether (50%, Ibiza Química Ltda, São Paulo, Brazil) for each luting cement used as described in Table 1.

Post Cementation

In the groups (NAB, SAB, NEB and SEB) dual-cure resin cement Bistite II DC (Bistite, J Morita, Tokuyama dental Corp, Tokyo, Japan) was used. Among these groups, the groups NAB and SAB had their canal walls cleaned with ethyl alcohol, while groups NEB and SEB had their canal walls cleaned with sulphuric ether. All cleaning agent excess was removed from post spaces with paper points. After that, post space walls were etched for 15 seconds with 37% phosphoric acid gel (SDI Ltda, Victoria, Australia), which was introduced with a needle, and rinsed for 15s with

Table 1: Experimental groups (n = 5)

Groups	*Sealer*	*Canal wall cleaning*	*Luting cement*
NAB	N-Rickert	ethyl alcohol	Bistite
NAZ	N-Rickert	ethyl alcohol	Zinc phosphate
NEB	N-Rickert	sulphuric ether	Bistite
NEZ	N-Rickert	sulphuric ether	Zinc phosphate
SAB	Sealer 26	ethyl alcohol	Bistite
SAZ	Sealer 26	ethyl alcohol	Zinc phosphate
SEB	Sealer 26	sulphuric ether	Bistite
SEZ	Sealer 26	sulphuric ether	Zinc phosphate

distilled water. Excess water was removed from post spaces with paper points.

For Bistite specimens, one drop each of Primer 1A and 1B (Bistite, J Morita, Tokuyama dental Corp, Tokyo, Japan) was mixed and applied several times during 30 seconds application time, gently air dried for 2 to 3 seconds and then had the Primer 2 applied with a microbrush for 20s and gently air dried for 3-5s. The primer-adhesive was applied to post space dentin with a microbrush. Excess primer-adhesive solution was absorbed with paper points (Dentsply Ltda, RJ, Brazil). For cementation of glass-fiber posts, equal amounts of a dual-polymerized resin luting agent (Bistite II DC) paste base and catalyst were mixed for 20s and applied to the post space walls with a lentulo spiral instrument (Dentsply/Maillefer, Ballaigues, Switzerland), as well as onto the post surface using a plastic spatula. Subsequently, posts were inserted perpendicularly with finger pressure into prepared RT and excess material was gently removed with an explorer. The light-curing was performed for 60s with halogen light-curing unit in direct contact with coronal end of posts. After this time, an oxygen-blocking gel (Air Barrier, Bistite II DC) was applied with dispensing tip to the bonding margins of Bistite II DC cement and remainder was light-polymerized for 60s.

In groups NAZ, SAZ, NEZ and SEZ, zinc phosphate cement (Biodinamica Ltda, PR, Brazil) was used. Among these groups, NAZ and SAZ had their canal walls cleaned with ethyl alcohol, and cement excess was removed from post spaces with paper points. Groups NEZ and SEZ had their canal walls cleaned with sulphuric ether and excess was removed with paper points.

For zinc phosphate specimens, the cement was mixed according to the manufacturer's instructions and then introduced into each post space using a lentulo spiral instrument (Dentsply/Maillefer, Ballaigues, Switzerland) as well as onto the post surface using a plastic spatula. Subsequently, posts were inserted perpendicularly with finger pressure into prepared RT and excess material was gently removed with an explorer. Finger pressure was maintained until the cement set and specimens were stored in distilled water at 37ºC for 7 days.

Tensile Test

Each root was notched and mounted in a special mounting apparatus that ensure posts were all in the same alignment for tensile testing. A plastic matrix of polytetrafluoroethylene with an inverted truncated cone shape of 5 mm diameter was placed around the coronal portion of the post and centrally adjusted. An incremental technique was used for the core build-up with a microhybrid composite resin Filtek Z 250, shade A2 (3M ESPE, Dental Products, St Paul, MN, EUA), each light-cured for 20s with a halogen curing unit. An additional 20s polymerization was subsequently performed from the bottom side of the cone.

For all steps that required a light activation, was used a light-curing unit (Ultralux Eletronic; Dabi Atlante, Ribeirão Preto, SP, Brazil), with an output of 600 mW/cm^2.

For the tensile tests was performed at a crosshead speed of 0.5 mm/minute using a universal testing machine (Instron Model 4440, Norwood, MA, USA). Forces were expressed in Megapascal (MPa).

The dislodged posts were observed by means of stereomicroscope (40X magnification), and failure modes were classified as adhesive (between resin cement and dentin), cohesive (within cement) and mixed failure (partially within cement and partially adhesive failures).

Statistical Analysis

Mean values were calculated for each group by three-way analysis of variance and Tukey's test (Minitab 14, Minitab Inc, Pennsylvania, USA) was used for pairwise comparisons among groups ($\alpha = 0.05$).

RESULTS

Mean retentive strength values (MPa) and standard-deviation (±SD) of the test groups are shown in Figure 1.

Three-way ANOVA revealed statistical significant difference for the factor 'cement' ($p \leq 0.05$), with higher bond strength values for the zinc phosphate groups (249.32 ± 35.96). Interaction 'sealer' and 'cement' was statistically

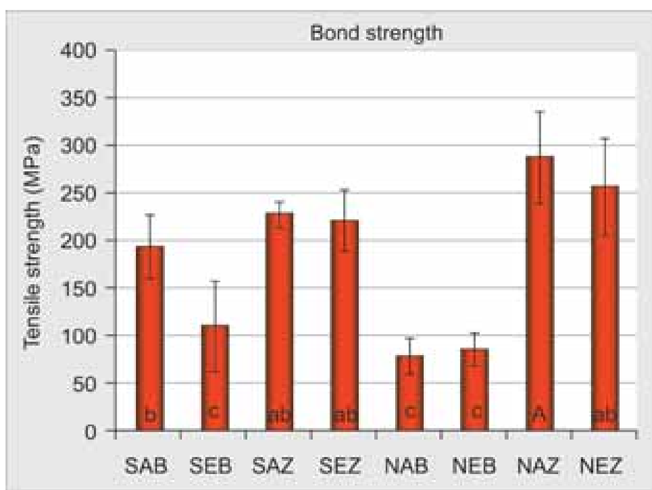

Fig. 1: Mean retention values and SD for experimental groups. NAB (N-Rickert + ethyl alcohol + Bistite), NAZ (N-Rickert + ethyl alcohol + Zinc phosphate), NEB (N-Rickert + sulphuric ether + Bistite), NEZ (N-Rickert + sulphuric ether + Zinc phosphate), SAB (Sealer 26 + ethyl alcohol + Bistite), SAZ (Sealer 26 + ethyl alcohol + Zinc phosphate), SEB (Sealer 26 + sulphuric ether + Bistite), SEZ (Sealer 26 + sulphuric ether + Zinc phosphate)

significant ($p = 0.0059$) with higher bond strength for the association of phosphate cement with both Sealer 26 or N-Rickert. All other factors and interactions were not statistically significant.

Fracture pattern showed that all dislodged posts that were cemented with Bistite were totally coated with luting cement, indicating an adhesive failure mode of the hybrid layer. On the other hand, all dislodged posts that were cemented with zinc phosphate presented its surface partially free of luting cement, indicating a mixed failure at the luting cement/post interface.

DISCUSSION

Retention loss of an intraradicular post is a frequent failure in dental rehabilitation that influences treatment success. Studies investigated the influence of various factors including post length,[11,12] post design[11,13] post diameter[12,13] post surface treatment,[14] cement type,[11,15] RT preparation diameter[16] root-canal sealers,[17] luting agent application mode[18] and operator skills.[19]

Our results showed that load required for dislodgment of posts cemented with zinc phosphate was significantly higher than that required for posts cemented with resin cement. These result is in accordance with other authors,[20,21] possibly due to the fact that N-Rickert contains eugenol, which could have affected the adhesiveness of the resin-based cement.

These results are consistent with those of previous studies,[8,9,22] which stated that resin-based cements should not be used with eugenol-containing materials because phenolic components of eugenol are free radical collectors and delay the polymerization of resin materials.[6,7] On the other hand, some authors state that chemical formulation of endodontic sealers did not affect the retention of posts cemented with resin.[20]

When zinc phosphate was used as a luting cement, no statistically significant difference ($p > 0.05$) was found between the groups filled with and without eugenol based sealer. Therefore, the eugenol-containing sealer (N-Rickert) did not interfere with the properties of the zinc phosphate cement, which yielded higher bond strength means.

Zinc phosphate cements offer several additional advantages over resin cements. They are generally easier to manipulate, require fewer steps than resin cements, less expensive and offer less opportunity for procedural mishaps.

The greater tensile bond strength of the posts fixed with zinc phosphate cement may be explained by the physical characteristics of this cement and its adherence does not involve any reaction with surrounding mineralized tissue or other restoration materials. The adhesion is mainly due to mechanical interlocking at interfaces rather than to chemical interactions.[23] Additionally, it has been demonstrated that zinc phosphate cement application technique can also influence post retention, and thus post surface and RT walls should be coated by a uniform cement layer.[24]

Some authors recommend the use of solvents immediately before post cementation[10] and they reported that guta-percha solvents have an adverse effect on bond strength of adhesive cements to dentin RT.

The additional ethanol application step was previously proposed in endodontics to dehydrate the RT before filling with gutta-percha and to completely dry the RT to evaluate the sealer coverage.[25] But in the present investigation, the ethanol-wet bonding technique was tested with a commercially available etch-and-rinse adhesive system to replace residual water with the bonding and to enrol exposed collagen fibrils.

As hydrophobic resins have higher stiffness and greater stability in an aqueous environment, thus improving longevity of adhesive interface when compared with hydrophilic ones,[26] it was recently proposed to replace residual water prior to the application of bonding agents with ethanol to facilitated the permeation of hydrophobic monomers into ethanol-saturated etched dentin.[27-30] The goal of this technique is to dilute and displace all water present at the hybrid layer base by ethanol, leaving unsupported collagen fibrils in an ethanol-moist rather than water-filled environment to allow relatively hydrophobic resins to impregnate substrate.[29] Despite promising results of ethanol-wet bonding technique when used on coronal dentine,[27-30] little is known regarding this technique when applied to lute posts to intraradicular dentine.

In our study, treating dentin surface with ethyl alcohol or sulphuric ether before cementation did not produce an increase in its retention. A possible explanation for the lack of effect of Bistite to ethanol and sulfuric ether pretreatment could be related to the difference in adhesive composition, as it contains acetone solvent in formulation instead of ethanol. The importance of ethanol or sulfuric ether application to properly replace water from intraradicular dentin still requires further investigations, especially to clarify if this technique may reduce the effect of aging and improve bond stability.

CONCLUSION

Under the limitations of this study, it was licit to conclude that despite the endodontic sealer used, higher bond strengths were obtained when posts were cemented with zinc phosphate.

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