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Original Article

Dentistry Section

Effect of Endodontic Retreatment Protocols on Bond Strength of Fiberglass Post to Root Canal Dentine: An In-vitro Study

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ABSTRACT

Introduction: Fiberglass Posts (FGPs) associated with composite resin foundation materials have become the primary alternative to restoring teeth with root canal treatment presenting excessive coronal destruction. Despite technical evolution, loss of retention between FGP and root dentine continues to be reported.

Aim: To examine the effect of endodontic retreatment protocols on the bond strength of FGP to radicular dentine.

Materials and Methods: This in-vitro study was conducted at Evangelical University of Goiás, Brazil from August 2019 to June 2020. A total of 30 freshly extracted bovine incisors were instrumented, filled and distributed into three experimental groups with 10 incisors in each groups. Group 1 was control, group 2 had incisors with gutta-percha removed using K-type files and group 3 had incisors with gutta-percha removed using ProTaper Universal Retreatment instruments. After root canal retreatment and re-sealing, the fiber posts were cemented into prepared post spaces using a resin-based cement. Roots were transversally sectioned into six 1 mm thick specimens. The push-out test was performed, and the modes of failure were evaluated. Data were analysed with two-way Analysis of Variance (ANOVA) and Tukey's test.

Results: There was no significant difference between the mean bond strength values in group 1, 2 and 3 with p-value >0.05. The cervical third of root canal presented higher bond strength values compared with the middle and apical thirds. However, significant differences were observed only for the control group (p-value=0.005). Adhesive failure between resin cement and radicular dentine was the most prevalent type of failure.

Conclusion: The endodontic retreatment protocol did not influence the bond strength of FGP to radicular dentine.

Keywords: Dental bonding, Post and core, Root canal therapy

INTRODUCTION

In recent years, FGPs associated with composite resin foundation materials have become the primary alternative to restoring teeth with root canal treatment presenting excessive coronal destruction [1,2]. The popularity of this technique is due to the favourable biomechanical properties of FGPs, which, in association with composite resin luting cement and adhesive systems, have enabled more durable, aesthetic, lower cost, simple, and less time-consuming final restorations [3-5]. Despite technical evolution, loss of retention between FGP and root dentine continues to be reported [6]. In addition, studies have demonstrated that the quality of adhesion at the dentine-cement-post interface can be negatively affected by the type of cementation method, adhesive system, and the root canal surface [7-12].

Root canal retreatment is often indicated where clinical and radiographic evidence of infection is still present or reappears after non surgical endodontic treatment [13,14]. Since the major goal of retreatment is to reinstate health in apical area [15,16], several protocols have been proposed for removal of the filling material and regaining access to the periapical tissues [17]. Removing gutta-percha using conventional methods, such as hand instruments, with or without solvents, ultrasonic tips, laser, and heat-carrying devices, can be a tedious, challenging and time-consuming process [15,16]. Nickel-Titanium (NiTi) rotary were designed exclusively to remove root canal obturation [17]. Their efficacy, cleaning ability, and safety have been previously demonstrated [15,16].

In the root canal retreatment, even after the chemo-mechanical reinstrumentation, sealer and gutta-percha residue may remain on the root dentine surface [18,19]. These materials may act as a mechanical barrier that may prevent hybrid layer formation and compromise the bonding inside the root canal [1,20,21]. Since the success of restorative procedures in teeth with root canal treatment are associated with the optimal bond between post cement and cement-dentine [7], efficient removal of root filling material is desirable [22].

Although several investigations have demonstrated the harmful consequences of endodontic practices on the bond strength of FGP to root canal dentine [1,8,11,12,23-26], only a few studies have been performed to precisely evaluate the influence of endodontic retreatment procedures [22,27-30]. To date, no research has focused on the effect of endodontic retreatment protocol on the push-out bond strength of FGP cemented with self-adhesive resin cement. Thus, the present study aimed to examine the effect of the endodontic retreatment protocol on the bond strength of FGP to radicular dentine. The null hypothesis tested was that there would be no disparities in bond strength of FGP to the root dentine due to the protocol for removing the root canal filling material (NiTi rotary instruments or K-type files) and level of the root canal.

MATERIALS AND METHODS

This in-vitro study was conducted study was conducted at Evangelical University of Goiás, Brazil from August 2019 to June 2020. Approval was taken from Institutional Research Ethics Committee (approval number 256/2010).

A total of 30 recently extracted bovine incisors with roots anatomically comparable in dimension and format, with a root canal less than 1 mm in diameter and totally formed apices were chosen for this study and stored in distilled water. Prior to root canal instrumentation (RCI), each tooth was decoronated using a double-faced diamond disc (KG Sorensen, São Paulo, SP, Brazil) to produce standardised roots 15 mm in length. The working length was established by subtracting 1 mm from the real root length.

Procedure

The canals were instrumented using a crown-down technique with K3® nickel-titanium rotary instruments (SybronEndo, Optimum, São Paulo, SP, Brazil) [8]. Apical enlargement was performed to 40/.02 file (SybronEndo, Optimum, São Paulo, SP, Brazil). During RCI,the canals were irrigated with 3 mL of 2.5% sodium hypochlorite (NaOCl; Pharm. Fitofarma, Goiânia, GO, Brazil) at each instrument change. After completing RCI, 3 mL of 17% EDTA was used to irrigate the root canals (Biodinâmica, Ibiporã, PR, Brazil) for 3 min, and then a final rinse with 3 mL of saline solution. Sterilised paper points were used to dry the root canals before the root filling with gutta-percha (Dentsply Maillefer, Ballaigues, Switzerland) and Sealapex sealer (SybronEndo, São Paulo, SP, Brazil), manipulated following to manufacturer instructions, using the cold lateral technique. The excess of filling material was removed, the coronal part of the canal was sealed with Vidrion R (SS White, Rio de Janeiro, RJ, Brazil), and all roots were stored at 37°C and 100% humidity for two months [22].

The roots were then allocated into 3 groups (n=10) according to the endodontic retreatment protocol.

- Group 1 was not endodontically retreated (control group);
- Group 2 had the cervical three mm of the root canal material removed using 0.50 (#2) and 0.70 (#3) mm Gates Glidden drills (Dentsply Maillefer, Ballaigues, Switzerland). The obturation was then progressively removed with #10 and #15 K-type files and orange oil (Biodinâmica, Ibiporã, PR, Brazil) until the working length was achieved, subsequently the following K3®instruments were used to re-prepare the root canal: 25/.10, 15/.02, 20/.02, 25/.02, 25/.04, 25/.06, 30/.02, 35/.02, 40/.02 and 45/.02.
- Group 3 received the same retreatment procedures as group 2, except that instead of Gates Glidden drills and K-type files, ProTaper retreatment files (D1, D2, D3) (Dentsply Maillefer, Ballaigues, Switzerland) were used to remove root canal filling material. A total of 1 mL of orange oil was used in each root canal (groups 2 and 3). During the retreatment, the canals were irrigated with 3 mL of 2.5% NaOCl. After the retreatment procedure, the canals were irrigated with 3 mL of 17% EDTA for 3 min, rinsed with 3 mL of saline solution, dried with sterilised paper points, and obturated as before explained. The canal openings were then sealed with glass ionomer cement (Vidrion R, SS White, Rio de Janeiro, RJ, Brazil), and the specimens were stored for one month at 37°C and 100% humidity. An experienced endodontist accomplished all intracanal procedures.

After the storage period, space for the FGP was created using 0.70 (#1), 0.90 (#2), 1.10 (#3), and 1.30 (#4) mm Largo drills (Dentsply Maillefer, Ballaigues, Switzerland) (working length 10 mm), which corresponded to 1.3 parallel-sided, serrated fiber posts (Reforpost #2; Angelus, Londrina, PR, Brazil). The canals were irrigated with 2.5% NaOCl at each change of drill. After the post-space creation,each canal was rinsed with 17% EDTA and sterile solution and dried with paper points. The FGP were cleaned with 70% alcohol, and a silane agent (Silano, Angelus, Londrina, PR, Brazil) was applied with a microbrush for 1 min. The resin cement (RelyX U100; 3M-ESPE, St. Paul, MN, USA) was manipulated following the manufacturer's orientations, added to the canal with an endodontic instrument, and applied on the FGP. The FGP was inserted to its entire depth with finger pressure, and the excess cement was removed after 1 min. After 3 min, the luting cement was light-cured using a 1200 mW cm^{-2} source (Radii-Cal; SDI, Bayswater, Australia) on a total of 120 s: cervical face specimen, along the axis specimen, and oblique to the buccal and lingual surfaces of the specimen (40 s each). The specimens were then stored for 24 hrs at 100% humidity and 37ºC. After this period, each root was sectioned perpendicular to its long axis using a double-faced diamond disc (4" diameter×0.012" thickness×1/2"; Arbor, Extec, Enfield, CT, USA) at low speed with water-cooling in a precision saw (Isomet 1000, Buehler, Lake Bluff, IL, USA). This method aimed to gain two slices of 1 mm in thickness from each region (cervical, middle and apical level) of the root, a total of six slices per root. The roots were submitted to a push-out test in a universal testing machine (Instron 5960 Dual Column Tabletop Testing Systems, Instron, Barueri, SP, Brazil) [8, 22]. It was applied a compressive load at 0.5 mm/min^{-1} in the apical-cervical direction until occurs failure. The bond strength in MPa was calculated by dividing the load at failure (N) by the bonded interface area. This area was calculated as follows: $A=2\varpi r\times h$, where A is the area of the bonded interface, $\varpi=3.14$, r is the radius of the post segment (mm), and h is the thickness of the post segment (mm) [4,7,23].

To determine failure mode, all slices were air-dried, and both sides were evaluated under a light microscope at X40 magnification (Carl Zeiss, Jena, Germany). The failure mode was classified into: (i) adhesive between the post and resin cement; (ii) adhesive between resin cement and root dentine; (iii) cohesive in cement; (iv) cohesive in dentine; (v) cohesive in the post; and (vi) mixed, between post, resin cement, and root dentine.

STATISTICAL ANALYSIS

The statistical analysis was performed using Statistical Package for the Social Sciences (IBM™ SPSS 21, IBM Co., New York, NY, USA). The normality was tested by the Kolmogorov-Smirnov test. According to it, the push-out bond strength data were in a normal distribution (p-value >0.05). The effects of endodontic retreatment procedures on bond strength were analysed using a two-way Analysis of Variance (ANOVA) in a split-plot arrangement, with the main plot for endodontic retreatment procedures and the subplots for root canal levels. The Tukey test was used for multiple comparisons (α=0.05). In addition, each type of failure percentage within each group was computed.

RESULTS

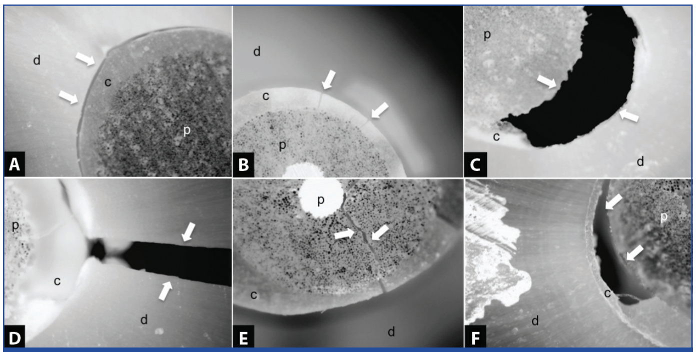
Push-out bond strength mean values and standard deviations for the groups are in [Table/Fig 1]. The two-way ANOVA revealed no significant influence of the factor endodontic retreatment procedure. No significant differences between the bond strength values of the control, K-type file, and ProTaper retreatment file groups (p-value >0.05) were observed. The cervical third of root canal presented higher bond strength values compared with the middle and apical thirds. However, significant differences were observed only for the control group (p-value=0.005). The failure mode details were mentioned in [Table/Fig 2]. Adhesive failure between resin cement and radicular dentine was the most prevalent type of failure, followed by cohesive in cement. Adhesive failure between post and resin cement was the less prevalent [Table/Fig-3].

Root third	Retreatment protocols			p-value
	Group 1	Group 2	Group 3	
Cervical	13.61±4.67^{A,a}	12.36±4.88^{A,a}	13.50±3.16^{A,a}	0.852
Middle	9.47±4.82^{A,ab}	10.43±4.10^{A,a}	10.22±4.48^{A,a}	0.894
Apical	6.74±2.98^{A,b}	6.23±4.49^{A,a}	6.85±3.27^{A,a}	0.964
p-value	0.005	0.185	0.096	

[Table/Fig-1]: Mean bond strength values in MPa (standard deviation) and statistical categories according to the Tukey test (n=10).
p-value: *ANOVA two-way; Capital letters compare groups in horizontal lines and lower-case letters in vertical lines; Tukey test categories with the same letter are not statistically different from each other (p-value >0.05 considered as statistically non significant)

Retreatment protocols	Failures modes [N (%)]						
	i	ii	iii	iv	v	vi	Total
Group 1	0	37 (61.67)	15 (25.00)	2 (3.33)	4 (6.67)	2 (3.33)	60 (100)
Group 2	1 (1.67)	36 (60.00)	11 (18.33)	7 (11.67)	2 (3.33)	3 (5.00)	60 (100)
Group 3	3 (5.08)	36 (61.02)	13 (22.03)	1 (1.69)	4 (6.78)	2 (3.39)	59 (100)

[Table/Fig-2]: Failure modes for experimental groups.
i) Adhesive: post and cement; (ii) Adhesive: cement and dentin; (iii) Cohesive: cement; (iv) Cohesive: dentin; (v) Cohesive: post; (vi) Mixed: post, cement and dentin.



[Table/Fig-3]: Light microscopy of failure mode: A) adhesive between resin cement and root dentine; B) cohesive in cement; C) mixed, among post, resin cement, and root dentine; D) cohesive in dentine; E) cohesive in the post; F) adhesive between resin cement and post. Arrows point to the failure region. d-dentine, c-cement, and p-post.

DISCUSSION

The results demonstrate that the type of protocol used for removing the root canal filling material (NiTi rotary instruments or K-type files) did not affect the bond strength of FGP to root canal dentine. However, the bonding to radicular dentine varied as a function of the different levels of the canal. Therefore, the null hypotheses tested in this study were partially rejected.

Previous studies have validated the push-out test (the experimental methodology used in the present study) to evaluate bond strength as advantageous and required to screen new materials/products and analyse different variables [9, 31-33]. Push-out tests present more consistent stress propagation and less inconsistent results [4,9,31,32]. Additionally, fewer specimens are waste in push-out tests, which appears to be more effective and safer than the micro tensile method [4]. It is important to note that the specimen's geometric parameters and the elastic module of dentine and intracanal materials may interfere with the bond strength measurement [34, 35]. In this sense, a comparison between results obtained from studies with different experimental setups should be made cautiously [20,34,35].

The present study used bovine teeth since human teeth are hard to gather for academic dental investigation [1,25,36]. Bovine teeth are easier to obtain, enable better age and canal space standardisation, and reduce the risk of transmitting infectious and contagious diseases [1,8,22]. Previous investigations have also showed that human and bovine teeth have comparable characteristics [8,20,23], making bovine teeth viable alternatives for human teeth in dentine or enamel bond strength studies.

This study selected a self-adhesive resin cement as it has high adhesion, long-term stability, and simplicity to use [9,37]. Self-adhesive resin cement was developed to adhere to the dental structure without requiring acid etching [6,29]. Its adhesion occurs through two distinct mechanisms: (1) the acidic monomers hybridise the dentin; and (2) the resin chemically interacts with hydroxyapatite [25,38]. Bitter K et al., found the chemical interaction between resin-based cement and hydroxyapatite is more relevant for radicular dentin bonding than the material's capacity to promote hybridisation of dentin [32].

The present study results indicated that the protocol used for root canal filling removal has no detrimental influence on the bond strength between FGP to radicular canal dentine. The utilisation of ProTaper Universal Retreatment instruments resulted in higher bond strength mean values, with no significant difference for the K-type file group. Unfortunately, no previous published studies on the influence of the root canal retreatment protocols on the bond strength of FGP cemented with self-adhesive resin cement to radicular dentine have been found, making it difficult to interpret and compare the results. However, Pelegrine RA et al., evaluated the effect of endodontic retreatment on push-out bond strength of two resin cements used for post cementation and observed that retreatment had adverse consequences on the push-out bond strength of Panavia F with ED primer, but not on RelyX U200 [29]. In the opinion of these authors [29], since the RelyX U200 mechanisms do not imply the creation of a hybrid layer and resin tags, the adhesion was not possibly affected by the retreatment.

Analysis by root canal level showed that all group's mean bond strength values were higher in the coronal and lower in the apical thirds, as demonstrated in other investigations [1,12,22,39,40]. Nevertheless, Gomes GM et al., [21] obtained higher bond strengths in the apical third than in other canal areas using self-adhesive resin cement. The lower values observed in the apical third may be explained by a large amount of filling material remaining in this region [17,38]. The presence of a great quantity of gutta-percha and sealer in the apical third, and the lack of a homogenous bond interface [1,20] could diminish the binding area between dentin and cementing agent, thus reducing polymerization of the resin cement [1]. Additionally, restrictions in the flow of the viscous cement, reduced accessibility to the apical region, the cavity configuration factor (C-factor) [4] and variations in the anatomical and histological characteristics of different regions of the root canal [39,41] may also contribute to these results.

In this study, most of the failures were adhesive and happened at the interface between root canal dentin and resin cement. This result agreed with earlier results confirming that FGP cemented with self-adhesive resin are weakest at the resin cement-root dentin interface [9,22,42]. This finding may be associated with residual obturation material on the root canal walls and inside dentinal tubules, and on the low ability of the self-adhesive resin cement for dentin hybridization [9,10,20].

Limitation(s)

The samples in this study were not subjected to thermal and mechanical influences, which may occur in the oral cavity.

CONCLUSION(S)

The root canal retreatment protocol did not compromise the bond strength of FGP to radicular dentine. However, future clinical studies are necessary to confirm the present study results and evaluate the effect of new root canal retreatment protocols on the long-term stability of composite resin build-up using FGP with self-adhesive resin cement.

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- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

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