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SEM ANALYSIS AND PUSH-OUT BOND STRENGTH OF FIBERGLASS POSTS LUTED WITH DIFFERENT CEMENTS OF GLASS-IONOMER IN HUMID ENVIRONMENT: PILOT TEST

ABSTRACT

The objective of this study was to evaluate the push-out bond strength of fiberglass resin reinforced bonded with five ionomer cements. Also, the interface between cement and dentin was inspected by means of SEM. Fifty human canines were chose after rigorous scrutiny process, endodontically treated and divided randomly into five groups (n = 3) according to cement tested: Group I – Ionoseal (VOCO), Group II – Fugi I (GC), Group III – Fugi II Improved (GC), Group IV – Rely X Luting 2 (3M ESPE), Group V – Ketac Cem (3M ESPE). The post-space was prepared to receive a fiberglass post, which was tried before cementation process. No dentin or post surface pretreatment was carried out. After post bonding, all roots were cross-sectioned to acquire 3 thin-slices (1 mm) from three specific regions of tooth (cervical, medium and apical). A Universal test machine was used to carry out the push-out test with cross-head speed set to 0.5mm/mim. All failed specimens were observed under optical microscope to identify the failure mode. Representative specimens from each group was inspected under SEM. The data were analyzed by Kolmogorov-Smirnov and Levene's tests and by two-way ANOVA, and Tukey's port hoc test at a significance level of 5%. It was compared the images obtained for determination of types of failures more occurred in different levels. SEM inspection displayed that all cements filled the space between post and dentin, however, some imperfections such bubles and voids were noticed in all groups in some degree of extension. The push-out bond strength showed that cement Ketac Cem presented significant higher results when compared to the Ionoseal (P = 0.02). There were no statistical significant differences among other cements.

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INTRODUCTION

From a mechanical and biological perspectives, the ideal restorations must preserve to the maximum remaining dental tissues. The challenge of restoring a tooth treated endodontically is how it should be done. The advances in endondontic therapy allow for the maintenance of tooth. However, the coronal area frequently requires the use of a post system in order to allow the aesthetic rehabilitation.[1]

The clinical decision-making process for choosing the most appropriated material to restore the endodontically treated tooth is still a challenge. Traditionally, a metal allow has been employed to restore it. However, due to it drawbacks and high elasticity modulus when compared to dentin tissue, recently resin-reinforced fiber (RF) posts have been pointed out as the first option since it presents mechanical characteristics nearest to the dentin, leading to reduced the risk to radicular fracture.[1-3] And better spread of stress along the root canal walls.[4]

The main failure mode reported to adhesively cemented RF is the debonding and it might be related to the deterioration of cement by functional loads resulted from masticatory efforts[5-8] and the susceptibility of hygroscopic changes[9]. Moreover, a variety of factors can affect the bond interface integrity, including the cavity configuration ("C" factor)[10] and the difficulty in controlling moisture.[6, 7, 11]

Various resin cements and adhesive approaches have been proposed to bond FRC posts to dentin over time. However, glass-ionomer cements have also been advocated to lute FRC posts to dentin.[12] The set reaction of glass ionomer cements may result in an enhanced adaptation to the root canal walls,[12] which may favor the friction resistance to post dislodgment. In addition, glass-ionomer cement has been used in high frequency in cementation of prosthetic crowns, especially full-crown metal-ceramic restorations[11,13]. The bond strength of this material is adequate and the recurrence of caries in the region of prepare is very low[14]. Glass-ionomer cements have properties that include the skill of ionic change with dental surface, liberating of fluoride by the whole durability of restoration and maintenance of marginal sealing by long periods. It is common knowledge that water is the main barrier for the effective bond to the tooth. Besides, manufacturer recommendations for the post settlement and the nature of reaction for the cement are points with influence in the procedure of post cementation.[5]

This study sought to analyze the push-out bond strength of four glass-ionomer cements and their relationship established with the dentin through Scanning Electronic Microscopy (SEM). The following hypothesis will be tested: there is statistical significant difference among cements evaluated.

MATERIAL AND METHODS

Fifty human health canines with similar dimensions, whose radicular length were 15 mm or more, without curvatures or cracks were chose. Teeth were obtained from Teeth Bank of University of South of Santa Catarina (Unisul), and they were properly stored in distilled water at 37ºC until they have been used, following to the rules required by Ethics Committee of Unisul.

The teeth crowns were removed with a steel diamond disc in low speed in a cut machine under water cooling (IsoMet® 1000 Precision Saw, Buehler Ltd., Illinois, USA). The radicular canal of each tooth was instrumented according to the step-back technique up to size #35 k-file (Dentsply Maillefer, Petrópolis, RJ, Brazil) in the apical region, according to International Standardization Organization – ISO. Irrigation was carried out with 2.0 ml of Milton solution (1.0% sodium hypochlorite) and EDTA (17% ethylenediamine tetra acetic acid) alternately, after every change of file. Afterwards, the tooth was washed in saline (0.9% NaCl) and dried with points of absorbing paper (Tanari, Tamariman Industrial LTDA, Macaçaruru-AM, Brazil). The lateral condensation technique using gutta-percha (Tanari, Tamariman Industrial LTDA, Macaçaruru-AM, Brazil) #35 and an epoxy resin-based obturator paste and calcium hydroxide (Sealer 26, Dentsply Maillefer, Petrópolis, RJ, Brazil) were used to filling the root canals. Subsequently, all teeth were stored at 37ºC in distilled water during 7 days long.

The root canal filling was partially removed using heated Rhein points. The post-space preparation was done by using a drill number 2 from Reforpost Kit (Angelus, Londrina - PR, Brazil) in low rotation. The deep post-preparation was set to 10 mm, maintaining a minimum of 4 to 5 mm of filling material remaining in apex. Next, canal teeth were irrigated with 1.0% hypochlorite and washed in distilled water. The fiber post Reforpost #2 (Angelus, Londrina, PR, Brazil) were tried into root, cleaned with 95% ethanol and dried with oil-free air.

Selected teeth were randomly divided in 5 groups (n = 3) according to cement: Group I – Ionoseal (VOCO), Group II – Lining cement (GC), Group III – Fugi II Improved (GC), Group IV – Rely X Luting 2 (3M ESPE), Group V – Ketac Cem (3M ESPE). All luting agents were mixed according to manufacturer' instructions. Subsequently, the mixed cement was applied on the fiber post surface and also inside canals using a size #30 Lentulo spiral filler (Dentsply Maillefer) mounted on a low-speed handpiece.

The posts were inserted inside the root canals using finger pressure, and the surplus was removed prior to light polymerization or the setting reaction (glass ionomer cement). To reproduce most accurately the clinical environment, all roots remained immersed in distilled water over the cementation steps at

37°C (Figure 1 and 2). Two millimetres of the coronal portion of the root remained above water to ensure that water did not enter the canal. A 3-mm thick composite resin core (Z100; 3M ESPE) was placed to seal the coronal access cavity.

Figure 1 - Apparatus used to keep the roots inside the water.

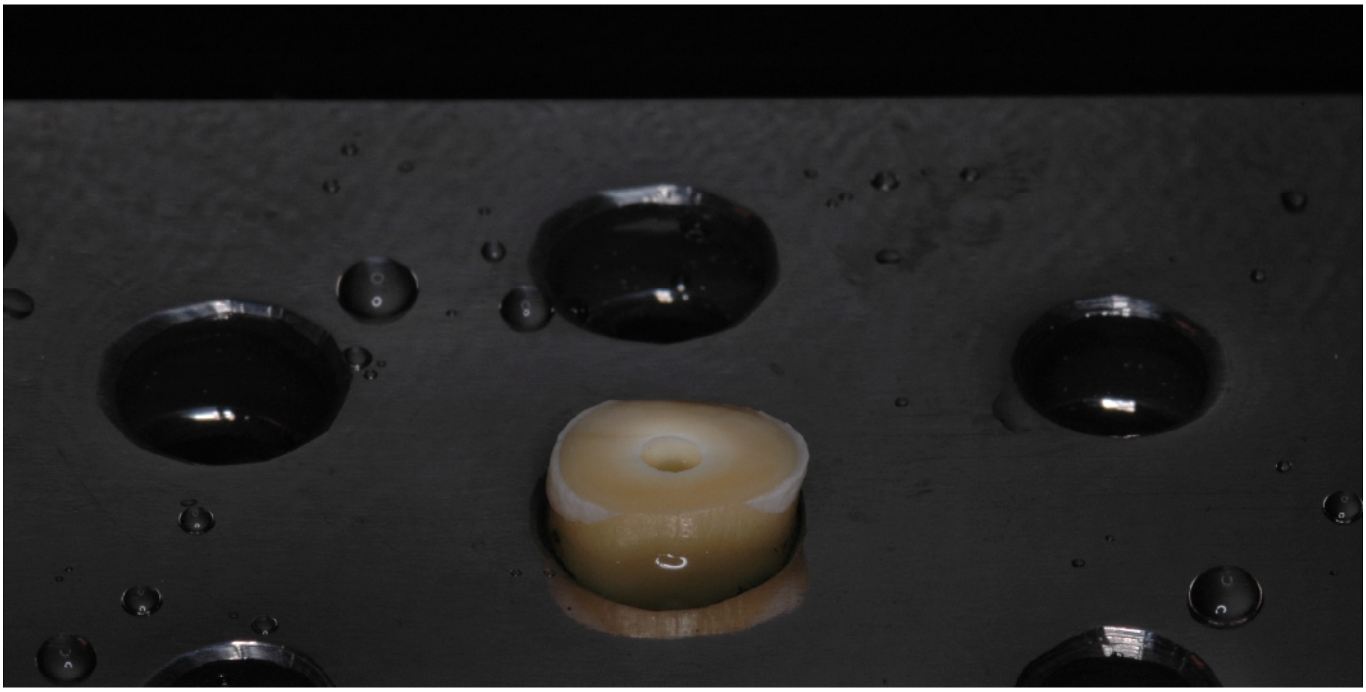
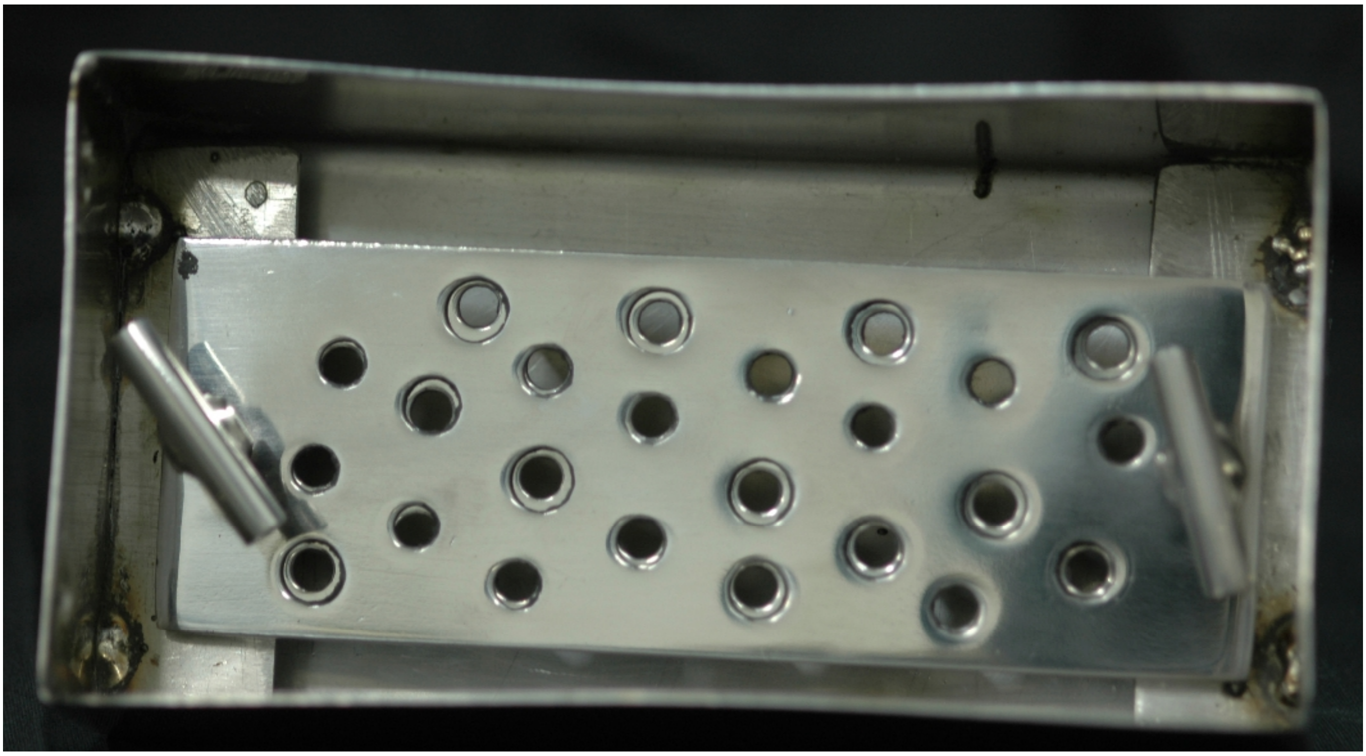


Figure 2. Root inside before and during cementation.



Each root was fixed in acrylic apparatus and cross-sectioned perpendicularly to its long axis with Diamond disc in high concentration (EXTEC DIA WAFER BLADE 4" X .012 X ½) attached to a metallographic machine cutter (Imptech PC 10), to obtain 1 mm thich-slices, removed from 1 mm, 5 mm, and 9 mm from the cervical limit. So, 45 specimens were acquired. All slices were marked with a marker pen (Pilot S.A) in red, green and blue colors to identify cervical, medium and apical regions, respectively. All specimens were stored in 37ºC distilled water in black containers in which the light cannot pass during 12 hours.

For Push-out test, each slice was positioned on a metallic device with a central opening (Ø=2 mm) larger than the diameter of canal. This test was performed in a universal testing machine (Emic DL – 1000, São José dos Pinhais, Brazil) at a crosshead speed of 0.5 mm/minute. A metallic cylinder (Ø extremity = 1 mm) induced a load in an apical to coronal direction on the post without applying any pressure to the cement and/or dentin. The maximum value for post dislodgement was recorded in Newtons (N) and the thickness of the canal diameter was measured with a digital caliper (Digimess, São Paulo, Brazil).

The bond strength (σ) in MPa was obtained with the formula σ=F/A, where F = load recorded for specimen failure (N) and A = bonded area (mm2). To determine the bonded interfacial area, the formula to calculate the lateral area of a circular straight cone with parallel bases was applied. The formula is defined as: A= πg (R1 + R2), where π=3.14, g= slant height, R1= apical radius, R2= coronal radius. To determine the slant height, the following calculation was used: g2 = (h2 + [R2-R1]2), where h = section height.

Microscopic analysis was performed in three regions: cervical, medium and appical. Representative specimens from the five groups were selected for SEM (MEV - JOEL 6460LV) analysis.

Kolmogorov-Smirnov and Levene's tests were used to evaluate the distribution and homogeneity of the data, respectively. Next, the data were analysed by two-way ANOVA and Tukey's post hoc test. The significance level was set $P < 0.05$.

RESULTS

The two-way ANOVA revealed that only the cement variable affected the push-out bond strength values ($P = 0.02$). The post level, in turn, did not influence the adhesiveness of fiber post to root dentin ($P = 0.22$) (Table 1). The Tukey's post hoc test demonstrated that fiber post cemented using Lining Cement, Lining Cement LC Improved, and Ketac Cem presented the highest bond strength to the root dentin, followed by RelyX Luting. Ionoseal presented the lowest bond strength values (P >

0.05). Moreover, the SEM images showed that the cohesive failure between cement and dentin was the major cause of failure all all groups.

Table 1 - Averages and standard deviation (MPa) of tested cements. Different latters point out statistical difference between groups evaluated.

Cements	***Polymerization system***	***Total average***	***Standard deviation (+/-)***
Ketac cem	Chemical	35.03[a]	8.21
Lining Cement	Chemical	27.81[ab]	6.93
Fuji II Improved	Photo activated	25.37[ab]	10.92
Rely x luting 2	Chemical	24.12[ab]	10.02
Ionoseal	Photo activated	21.01[b]	9.67

DISCUSSION

Although from a scientific point of view the monobloc concept is regarded as strictly theoretical, achieving a strong and suitable bonded interface especially between luting agent and dentin play the most important role in long-term survival when placing a fiber post adhesively bonded. However, understanding and acquiring such goal is still critical, since a plethora of combination among agent luting, adhesive strategies and dentin pretreatment area available. Also, several factors can negatively affect the bond strength as cavitor factor ("C" factor), humid, light access to apical areas, higher concentration stress associated to resin-based cements, among others.[6,7,10,11]

Fiberglass posts delivery better qualities (aesthetic and failure modes) than metal posts and perhaps for above-mentioned factors; it has been widely employed replacing metal posts in some clinical situations. Not less important, but its usage means reduced time required to rehabilitate an endodontically treated tooth and also reduce potentially the risk of irreversible radicular fractures.[2,4,7]

Perhaps the major argument to support its employment is based on the fact that its flexural strength and elasticity modulus are quite similar to the root dentin, what do not happened with other type of material as stainless steel, titanium alloy, gold alloy and zirconium oxide.[2,4,7]

The ability of fiber posts withstanding to loads with potential to produce adhesive failures (post dislodgment) is more related to friction established between dentin and cement than bond strenght.[12] Recently, a study revealed that glass-ionomer delivered better bond strength when compared to self-adhesive cements.[15] As a possible explanation for such outcome was based on the fact glass-ionomer cements get benefits from hygroscopic expansion, leading to an increased frictional strength.[8]

Although the Ketac Cem outcome has been statistically different from Ionoseal results, it did not show differences when compared with remain groups. However, Ketac Cem presented the highest bond strength. Although conventional ionomer cements and the resin modified ionomer cements show hygroscopic expansion, they suffer contraction before hygroscopic expansion during the polymerization reaction.[8] However, this expansion occurs in a gradual way because the hydrophilic resin present in its composition absorbs water slowly[5-9]. In addition, the hygroscopic expansion after maturation of glass-ionomer and glass-ionomer reinforced by resin compensate their contraction of initial settlement, what results in a higher adaptation of the cement to the substrate.[8] Nevertheless, because they possess methacrylate groups or monomers (glass-ionomer reinforced by resin) that can be polymerized, the expansion of glass-ionomer modified by resin is not so significant[13]. These reasons might explain the better bond strength and interface adjustment noticed between dentin and conventional glass-ionomer cement than other cements.

With the chemical modifying of conventional glass-ionomer cement by the addition of methacrylate groups or monomers subject to polymerization, it was possible achieving a chemical bond to the calcified tissue, in combination to the benefits from the resin, as a better compressive strength, and strength to the fracture and to the abrasion[16]. Besides, the material shows being stronger to oral fluids; whereas there is the possibility to be photo activated and also has the property of bond to composite materials[5]. Because they need photo activation, the light hardly achieves apical and middle third with the same effectiveness than the cervical third, which is the reason why, even filling all the interface in-dentin, ionomer cements in modified glass by resin did not achieve the better results in this study.

CONCLUSION

Within the limitations of this study, the study hypothesis that postulated that there is statistical significant difference among cements evaluated was accepted since a significant difference was observed among groups evaluated.

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