

Analysis of Bond Strength by Pull Out Test on Fiber Glass Posts Cemented in Different Lengths

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Abstract:

Background: The aim of this study was to evaluate, by means of pull-out test, the bond strength of fiberglass posts when cemented with different lengths in endodontically treated teeth.

Materials and Methods: Sixty single-rooted bovine roots were cut in the cemento-enamel junction with 21 mm length. They were endodontically treated and randomly divided into three groups ($n = 20$). Group 1 - Preparation of 2/3 of the remaining roots; Group 2 - Preparation of 1/2 of the remaining roots and Group 3 - Preparation of 1/4 of remaining roots. For all groups it were used posts $n = 3$ (Exacto, Angelus, Brazil), and cemented with self-etching resin cement (RelyXU200). After cementing posts, the samples were thermocycled (10.000 cycles/5°C and 55°C). The pull-out test was performed on a universal testing machine (EMIC - DL500) and the values obtained were statistically analyzed by analysis of variance (one-factor ANOVA) and multiple comparison test of Tukey, with level of significance of 5%.

Results: The mean values \pm standard deviation in Newtons (N) were: Group 1 = 120.5 (± 42.8) A, Group 2 = 103.1 (± 31.2) AB, Group 3 = 41.2 (± 22.4) C, $P < 0.005$.

Conclusion: The preparation of 1/2 of remaining root appears to be a viable alternative when 2/3 of the preparation of the remaining root is not possible, but more results are needed for clinical validation.

Key Words: Bond strength, fiber post, pull-out test, resin cements

Introduction

Endodontically treated teeth, unlike vital teeth often need a docking intraradical to be restored.¹⁻³ Teeth in which more than 50% loss of the coronary need intraradical posts to retain restorations mainly on previous elements, providing extra strength to the restoration, either directly or indirectly.⁴

Intraradical retainers are increasingly used in dentistry for direct and indirect restorations, and the fiberglass posts are an excellent choice at the expense on metal posts due to advantages such as corrosion resistance, good cosmetic

results, ease of removal in cases of endodontic retreatment, cementing and restore in a single session.^{5,6} The remaining root, their size, and shape, determine the selection of post. Holmes demonstrated, in 1996 that the major length of the post results in greater retention and stress distribution. When the remaining root is short and curved, the use of a greater length for these posts is impeded.⁷ *In vitro* studies have demonstrated that reducing the length can be compensated using cements reinforced with resin.⁸ The technique of using fiberglass post associated with adhesive restorative materials can promote a long clinical success for endodontically treated teeth.⁹

Many published studies have evaluated intraradical bond strength associated with resin cements and adhesive systems.¹⁰⁻¹⁸ Few studies made an attempt to evaluate the technique of this procedure. So far, the standard removal procedure flue is 2/3 of root length, however, some teeth are contraindicated because of their anatomy and root diameter.¹⁹⁻²¹

The aim of this study was to evaluate by pull-out test, the bond strength of fiberglass posts cemented with different lengths in endodontically teeth.

Materials and Methods

A total of 60 bovine incisors with similar lengths and diameters were selected. Using diamond disc (K Sorensen, Barueri, Brazil) in the straight hand piece, the teeth were sectioned at cemento-enamel junction standardizing root length in 21 mm, and the crowns were discarded.

The roots were fixed at the tip a paralelometer (Bio Art, São Carlos, SP, Brazil) by the aid of a godiva stick by the center of PVC connection embedded with chemically activated acrylic resin until complete polymerization of the resin. The roots received endodontic treatment standardizing the length of 21 mm at all. It was used Kerr files (Dentsply Maillefer, Switzerland) until number 60 and concurrent irrigation with 1% sodium hypochlorite.

The specimens were randomly divided into 3 groups ($n = 20$) and after 24 h of desobturation with the drill guide (post no 3. Exacto/Angelus, Londrina, PR, Brazil) as follows: Group 1: Removal procedure with 2/3 of the length = 14 mm Group 2: Removal procedure with 1/2 of the length = 10.5 mm and Group 3: Removal procedure with 1/4 of the length = 5.25 mm.

After the division of the groups the posts were disinfected with 70% alcohol and ducts cleaned with sodium hypochlorite 1%, saline solution and dried with absorbent paper cones (Tanari Industrial Manaus, Brazil). The cement used was RelyX U200 (3M ESPE - USA) which was dispensed on a block of paper, spatulate and inserted into the canal with the aid of a Centrix syringe with needle tips according to manufacturer's instructions. The posts were inserted the excess of resin cement was removed with an explorer probe and light curing for 40 s (Optilight LD MAX - Gnatus).

The specimens were subjected to thermocycling (10.000 cycles/30 s/3 s/5°C and 55°C) (Nova Etica, Model 521-E, Ethics Scientific Equipment S/A, São Paulo - SP, Brazil). The number of cycles corresponded to 12 months aging.²²

After thermocycling it was made loops on the end of the device for Pull-out test. It was made a hole with a 2200 diamond bur (KG Sorensen) at high speed and thoroughly it inserted stainless steel wire coated for nylon. Then, a reinforcement of chemically activated resin was positioned at the end of the device to minimize possible disruption effect of tensioning before the pull-out test.

The pull-out test was carried out on a universal testing machine (EMIC - DL500) at a speed of 0.5 mm/s until the total traction of the fiberglass post, and the results were statistically evaluated.

Two pins Group 2 and two pins Group 3 come loose after thermocycling, and some posts broke during the test. Finally, for statistical analysis, these samples were discarded, and the final number of samples for each group was: Group 1: $n = 13$, Group 2: $n = 17$ and Group 3: $n = 17$.

The results were analyzed using analysis of variance (one-factor ANOVA) test and Multiple Comparison Test of Tukey at a significance level of 5%.

Results

The results are described in Table 1.

Using Tukey's test, it was compared the averages on Group 1 and Group 2, and there was no difference statistically significant between them. Comparing Groups 1 and 3, there was the difference statistically significant ($P < 0.01$) as well as in the comparison between Groups 2 and 3, which also was statistically significant ($P < 0.01$).

Table 1: Mean values±standard deviation for bond strength (Newtons) for each experimental group.

Group 1	Group 2	Group 3
120.5 (±42.8) A	103.1 (±31.2) AB	41.2 (±22.4) C

Different letters mean statistically different, $P < 0.0001$

Discussion

The bond strength of adhesive systems and resin cements to root dentin have been studied by several authors in recent years.^{10-12,18,23,24} However, the methodology, the preparation of the substrate, the materials used, among other factors show very different values.²⁵ Few studies, however, evaluate the influence of the length of cementing on the bond strength of fiber posts.^{15,16,25-27}

For many years, the standard assigned an optimum length for a retainer intraradical is 2/3 of root length or greater than or equal to the size of the crown.¹⁹⁻²¹ However, some teeth are contraindicated for this pattern due to the anatomy, diameter, and root remnant. PINZETTA²⁸ analyzed 67 panoramic radiographs containing premolars restored with intracanal posts totaling 96 teeth, which were observed proportion post intraradical/root length. It was found that 96.9% of the length of the post was lower than 2/3 of the length of the root and only 3.1% of the samples had a length equal to or greater than 2/3. The results of their study suggested the high rate of teeth contraindicated for this technique.

BRAGA²⁹ studied in 2006 bond strength of fiberglass and metal posts with different lengths; 60 samples were divided into three groups according to the length (I = 6 mm, 8 mm, II and III – 10 mm). Each group was divided into two subgroups based on material posts (metal and fiber). All posts were cemented with Panavia. Results showed that with post 10 mm long had higher tensile strength, regardless of the material of the post, and that post with 8 mm in length are similar to posts with 10 mm and clinical circumstances, where there are variations of roots (short or curved), posts with 8 mm may be a viable alternative.

The length of intraradical post is questionable, especially for short root remaining teeth or curved. SEN, 2004, obtained results by *in vitro* study that cements reinforced resin can compensate for the reduced length of the post since it combines adhesion to frictional retention.⁸

There are several studies are using bovine teeth instead of human's on researches about Bond strength of fiberglass posts.^{16,30-33}

It was used fiberglass post $n = 3$ Exacto (Angelus, Londrina, PR, Brazil). It was chosen because it has a diameter compatible to bovine roots, and it has an appropriate format to flow the cement. Reducing hydrostatic pressure during seating of the post and avoid an increase of stresses in the root canal, which may lead to fracture of the root.^{34,35} It was used, in this study, the centrix syringe for insertion of the resin cement, following the manufacturer's instructions. There is good evidence in the literature for this method, as described by Michida evaluating the influence of methods of inserting resin cement on the bond

strength of a reinforced fiberglass to radicular dentine and the quality of the cement layer. They concluded that the fiberglass posts can be cemented with the aid of lentulo drill to promote the best results in cementation.³⁶

The adhesive resin cements eliminate the pre-treatment of dental substrate, which is the stage of completion of washing and conditioning the enamel and dentin prior to cementation, preventing the breakdown of collagen fibers and loss of permeability to adhesives monomers.³⁷ By being self-etching adhesive and have reduced working time and supposedly safety because a simpler process with fewer steps while running, fewer errors occur. These cements have in their composition the acid that demineralizes enamel and dentin, and hydrophilic monomer infiltrating these structures resulting in a strong union.²⁴ In this study, it was used the self-adhesive cement RelyX U200, among the various materials available in the market because it is a relatively new material and the object of further research. The self-adhesive cement RelyX U100, its predecessor, has a high value of bond strength compared to other materials available for cementation of fiberglass.³⁸ Amaral compared the bond strength of the cement to conventional resin cement after undergoing mechanical cycling and proved the superiority of this cement in the adhesion of fiber glass post.¹⁰ The choice of self-adhesive and self-etching cement was based on results of Soares,⁶ in 2012, that evaluated the effect of cementing agent and design of fiber-glass post on the bond strength at different lengths in the root. They concluded that the retention of fiberglass posts remained unchanged by the surface roughness of the posts, but it was influenced by the type of resin cement, and the cement self-adhesive RelyX Unicem was significantly tougher. BERGOLI, 2012 found in the self-adhesive cement RelyxU100 a good alternative for cementation of fiber posts, because it showed higher bond strength through push-out test and the lowest values of polymerization stress. These results justify the increased use of these cements clinically and on scientific research.³⁹

The ISO TR 11405 (1994) and ISO TS 11405 (2003) indicate an appropriate test as an artificial aging compound in water for 500 cycles between 5°C and 55°C. In turn LELOUP,⁴⁰ in a study reviewing data published between 1992 and 1996, concluded that thermal cycling has no significant effect on bond strength, suggesting that this number of cycles was probably too low foraging to be obtained. Nevertheless several studies have demonstrated the negative effect of thermal cycling on Bond strength after a large number of cycles such as 15,000-30,000 cycles.⁴⁰⁻⁴³ Gale and Darvell, evaluated laboratory methods to simulate the temperature changes that occur in the oral cavity and the best method of aging on research samples. They concluded that thermal cycling, although they did not find evidence in the literature that could

interfere in the results of the research should be conducted to have proven its clinical relevance. They also concluded that the number of cycles corresponding to 12 months of aging is 10.000. In order to simulate the temperature variations experienced by the tooth in the oral cavity and the aging of the samples it was performed the thermocycling in this study where the specimens were submitted to 10,000 cycles of 30 s in each bath, with an interval of 3 seconds in temperatures of 5°C and 55°C, corresponding, according to this author to aging for 12 months.²²

The initial number of samples was 20 specimens in each group (Group 1: $n = 20$; Group 2: $n = 20$, and Group 3: $n = 20$). During thermocycling two samples of Group 2 loosened and 3 samples of Group 3. DE MUNCK, 2005, suggest that normally, even in short periods of water storage, the specimens show a decrease in bond strength. This decrease in bond strength may be caused by the degradation of the components of the adhesive interface, caused by the hydrolysis process. In Group 1, 7 samples were lost by breaking the post or the disruption of strap made to carry out the tensile test before full traction of post pin.⁴⁴

The evaluation of this study, unlike most in the literature, is based on a single variable: The length of the post. The pull-out test was chosen, because the results in shear force are comparable to clinically foundings, although few studies are reporting this methodology.^{44,45} This method better distributes stress, and it is considered able accurately to measure the bond strength between the post and root dentin.^{23,46,47} The pull-out test is more suitable than the push-out when the objective is to measure the holding force of the post along the duct and the type of craze.^{48,49}

Innella *et al.*,⁵⁰ Ferrari and Mannocci,⁵¹ highlighted the bond strength significantly higher in the cervical region, a fact that occurs for two reasons: reduction of dentinal tubules in mm^2 in the apical direction, and difficulty of the technique due to the accumulation of fragments at the walls of apical third. This could be an explanatory factor for the equality of results between Groups 1 (14 mm) and Group 2 (10.5 mm).

Another relevant factor is the density and distribution of dentinal tubules, which decreases significantly from coronal region toward the apical region of the root canal, and is related to the bond strength. In studies reporting evaluation of bond strength by cutting the cervical, middle and apical, through the push-out test, show that the apical adherence is critical due to the remnants of gutta-percha in the root canal wall, difficult access, difficulty of cleaning beyond narrowing of the diameter,⁵⁰⁻⁵⁶ however, the results obtained in this study with Group 3 (5.25 mm) showed lower values compared with the other groups.

The significant difference between Groups 1 and 2 (14 mm and 10.5 mm in removal procedure, respectively) compared to Group 3 (5.25 mm removal procedure) corroborate the findings by Macedo *et al.*¹⁵ that evaluated the influence of the length cement retention of fiberglass and concluded that improvement in retention post occurred with increasing length of cementation.

Macedo *et al.* assessed the effects of length of fiber cement and glass retention after subjected to artificial aging. It was tested bovine incisors endodontically treated that had fiberglass posts cemented with 5 mm or 10 mm of length. These posts were cemented with RelyX ARC and RelyX Unicem with others. The samples were subjected to aging by thermal cycling and/or mechanical cycling and then be pulled by pull out test. The control group did not undergo cycles for aging. They concluded that independent of aging protocol, greater depth (10 mm) showed higher bond strength than the samples of 5 mm, except for RelyX Unicem without thermocycling. And the effect of artificial aging on the tensile strength depends on the type of material used in cementing and depth.¹⁶

Due to the scarcity literature on the subject, it is suggested that further studies be conducted on different methodologies on the cementation of posts and removal procedure of root canal.

Conclusion

The preparation of the remaining root ½ appears to be a viable alternative when 2/3 of the preparation of the remaining root is not possible, but more results are needed for clinical validation.

Clinical significance

The results of this study can influence the clinical procedures in cementation of fiberglass posts because the bond strength values of posts cemented with ½ length were similar to those cemented with 2/3 of the length. It may suggest a more conservative cementation technique and it can allow the cementation of posts when the root canal is curved.

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