Comparison of different fiber post systems using push-out bond strength test

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Background and Objective: Nowadays, the use of fiber post in weak teeth that had root canal treatment has gained acceptance worldwide. New materials and shapes of fiber posts were introduced. This study was conducted to compare in vitro bond strength among Bundle glass fiber posts, taper glass fiber post and short fiber-reinforced composite as post material.

Methods: Thirty Mandibular premolars were divided into three groups according to the post material that used: 1. Taper fiber post cemented with resin core10 samples. 2. Bundle fiber post cemented with resin core ten samples. 3. Short fiber reinforcement composite used instead of post and cement ten samples. Each root specimen cut into three slices of 2 mm thickness from each cervical, middle, and apical part of the posts. Push-out tests were performed using a universal testing machine at three sites in each root at a crosshead speed of 0.5 mm/min.

Results: Micro push-out bond strength of the posts to dentin was not significantly affected by the type of post material ($p > 0.05$). Push-out bond strength values of cervical segments were significantly higher than the middle and apical segments in all groups ($p < 0.05$).

Conclusion: The Bundle fiber post exhibited higher bond strength than other posts, but it was not significant, the highest bond strength was observed in the cervical third of all post spaces. Short fiber reinforced composite represented comparable bonding performance with taper Post and bundle fiber post when it was used instead of post material.

Keywords: Fiber post, bundle postx bond strength, short fiber-reinforced composite.

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Introduction

The adhesive dentistry improves dramatically in restoring fractured teeth. Despite that many clinicians still using methods like prefabricated metal posts with a high rate of success, but also they have a lot of drawbacks, fiber posts give a lot of advantages and reduce the catastrophic failures in teeth that had been restored.[1, 2]

Modulus of elasticity for glass fiber post is similar to dentine, allowing better dissipation of masticatory loads through the tooth, which does not occur with metal posts, besides, glass fiber posts have several advantages, such as better aesthetic and corrosion resistance.[3]

Maintaining weakened teeth in the dental arch is a big challenge for most dentists, to preserve function and aesthetics, this issue has led to the development of alternatives to improve the retention of glass fiber posts and enabling coronal restoration in these roots, such as the

use of accessory fiber posts or new system as bundle post, a thick layer of luting cement and the association of composite resin with glass fiber posts to obtain customized well-fitting posts.[4,5]

A German company developed a new type of dental posts which is a radiopaque, translucent, glass fiber-reinforced composite post which exhibits dentine-like elasticity and ensures a considerably stronger bond to the core build-up than conventional root postswhich is basically a bundled post. This new approach is not a single post but rather composed of a bundle of thin individual posts. Once a sleeve is removed, the bundle is spread in fine individual posts that are distributed in the entire root canal, which adapt optimally to suit any root canal anatomy. Accordingly, this approach can be used in situations where strongly curved root canals or oval root cross-sections.[6]

Nowadays, mechanical properties of short fiber-reinforced composite (SFRC) is widely investigated, which are superior to traditional composite materials. Bond strength of short fiber reinforcement composites (used instead of post) to root canal dentin is promising because of no luting cement between dentin walls and fiber-reinforced composite. [7]

Till now there is no published research paper comparing push-out bond strength test of Bundle post system (Rebilda GT), with fiber posts that exist in the market or short fiber-reinforced composite used instead of a post.

Materials and methods

Sample selection and preparation. Thirty intact freshly extracted human mandibular premolars, extracted for orthodontic reasons, radiographic images obtained from the mesiodistal and buccolingual views to exclude teeth with calcifications, anatomic abnormalities, signs of internal resorption or previous endodontic treatment. Teeth were stored in normal saline solution at room temperature. Teeth decornated at the cementum-enamel junction from buccal side of each tooth 9 and the roots adjusted to have the same length 12 mm. 2 The working length of each canal determined by inserting a size 15 K type file (Dentsply, Malifer, Switzerland), and file reduced 1mm from the measured working length.

Root canal instrumentation and obturation. The roots prepared with the PROTAPER® Next rotary files (Dentsply Tulsa Dental, Tulsa, Oklahoma) driven at 250 rpm with 2N/cm torque (X Smart, Dentsply, Maillefer). up to size (X3) with Root Canal Preparation Cream EDTA (SURE-PREP, Sure Endo, KOREA) and 2 mL of 5.25% sodium hypochlorite (NaOCl) irrigation between each file size. After that, the canals received final irrigation of 5 mL 17% ethylene diamine tetra acetic (EDTA) acid and 5 mL 5.25% NaOCl, after that the canals flushed with 10 mL distilled water to avoid the prolonged effect of EDTA and NaOCl.1

The canals subsequently dried with paper points size (F3). Finally, the canals obturated with single cone technique using size (F3) gutta-percha cones (Dentsply–Maillefer, Ballaigues, Switzerland) in conjunction with AD SEAL root canal sealer (META BIOMED CO.LTD, Korea).

After the completion of endodontic treatment, cervical root canal openings were filled with Temporary filling material MD-Temp (META BIOMED, KOREA).All teeth stored at 37°C and 100% humidity for 24 hours in an incubator to allow setting of the sealer.[2]

Fiber Posts Procedures and grouping. Specimens were prepared by the same operator at 22.0–22.5°C and relative humidity of 50 +/-10%.

The roots were randomly assigned to three groups for the post type:

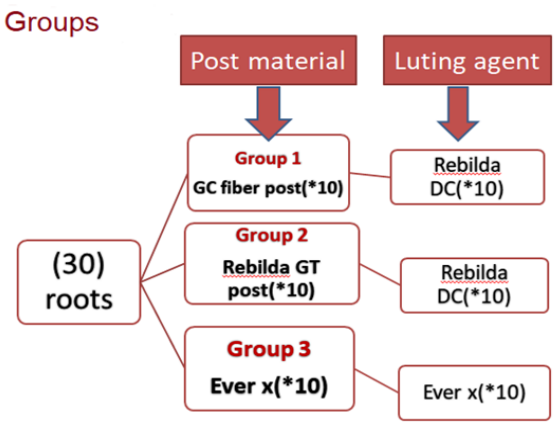


Figure 1: Grouping.

(1) GC Fiber Post, GC America 1.4 mm in diameter tapered posts n = 10, cemented with Rebilda DC, Voco. Cuxhaven, Germany (2) Rebilda GT Voco Cuxhaven, Germany 1.4 mm in diameter bundle post n = 10, cemented with Rebilda DC, Voco. Cuxhaven, Germany (3) Short FRC Ever X Posterior GC Corp., Tokyo, Japan n = 10 used instead of post-material and cement,

After 24 hours, the temporary filling was removed using spoon excavator and the gutta-percha removed with PROTAPER® universal Retreatment files (Dentsply) leaving a minimum 4-mm to ensure a clinically acceptable apical seal. A post space was prepared to a depth of 8 mm.[1] Peeso reamers number (1) to number (3) used in this study with all groups then fiber post drills of GC fiber post system diameter 1.2 then 1.4 used with all roots because in Rebilda GT system have no drills and compatible with all drill systems as manufacture instructions. All the prepared root canals finally flushed with 2-mL NaOCl solution (5.25%) and dried with paper points Dentsply–Maillefer.[1]

Before cementation, each fiber post was disinfected with alcohol and dried with air free of water then a silane coupling agent (Ceramic Bond, Voco) applied to the bonding surface of each post and allowed to act for 1 min and air dried as manufacture instruction.

After applying self-etching and dual curing bonding agent (Futurabond U Voco Cuxhaven, Germany) for20 s, the root canal was gently dried with air syringe and not light cured as manufacture instructions then the core-built-up composite (Rebilda DC, VOCO Germany.) inserted into the canal using application tip for first two groups: GC fiber post and Rebilda post Gt, after that the post inserted and light cured using a LED light-curing unit(Dia-lux, Dia Dent Korea)1600mW/mm^2 intensity for 40 seconds in each of four directions (buccally, lingually, mesially, and distally).[7, 8]

In the third post group, the same post space was prepared, as mentioned previously. Ever X Posterior was used instead of both post -material and luting agent to fill the post space which will be inserted into the canal with a small micro brush in increments; each increment will be 2mm and light cured for 20 seconds as manufacture instructions until the post space is fully filled. Therefore, no additional luting agent will be used in this group. [7] Specimens stored at 37 C and 100% humidity for 24 hours in an incubator to allow setting of the luting agent.[7]

Root sectioning. The root sectioned using (0.3) mm in a thickness of diamond-coated blades in a linear precision cutting device (Micra Cut 176, Metkon, Turkey). Each root specimen cut into three slices of 2 mm thickness from each coronal, middle and apical part of the roots. So each group had 30 test specimens.[9]

The push-out bond strength test procedure. For the push-out bond strength test, Universal testing machine (TERCO, MT 3037, Sweden) used. The rod diameters were 0.6mm and 1.0mm and special base for holding specimens had been manufactured shown in Fig 2.

The posts inside the specimens were loaded on the apical to the coronal direction. The punch pin was positioned to contact only the post, without stressing the surrounding root canal walls. The speed was 0.5 mm/min at room temperature 25 Celsius each specimen measured in height and width to determine the middle of each specimen. The maximum push-out force for bond failure recorded in (N) but the retentive strength of the post segment will be expressed in MPa.[9]

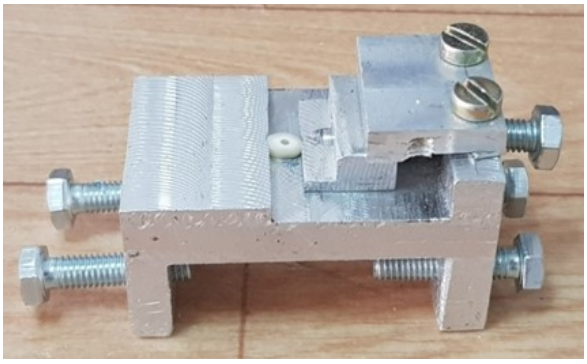


Figure 2: The special base for holding specimens

The formula that used for calculating the total bonding area for each post is:

De bond stress (Mpa)= De bond force (N) / Area of the post(A)

The adhesive surface (A) was calculated using :**(Equation 1) $A= 3.14\times L\times(R_1+R_2)$**

where A is the adhesive surface (mm^2), L is the slant height of the inverted cone (mm), R_1 is the smaller base radius of the post

(mm), and R_2 is the larger base radius (mm). The slant height was calculated using :
(Equation 2) $L = [\, H^2 + (R_2 - R_1)^2 \,]^{½}$

Statistical analysis

The collected data were analyzed by using SPSS (Statistical Package for Social Service), and the following statistic was used:

1- Descriptive statistics Means, Maximum and Minimum, Standard deviations, and graphical presentation by a bar chart.

2- Inferential statistics which included: Analysis of variance (ANOVA) test to determine if there is a significant difference among the means of groups. Then Tukey's HSD For comparison among the groups after using ANOVA test.

The null hypothesis H_0: $\mu_1 = \mu_2 = \cdots \mu_n$

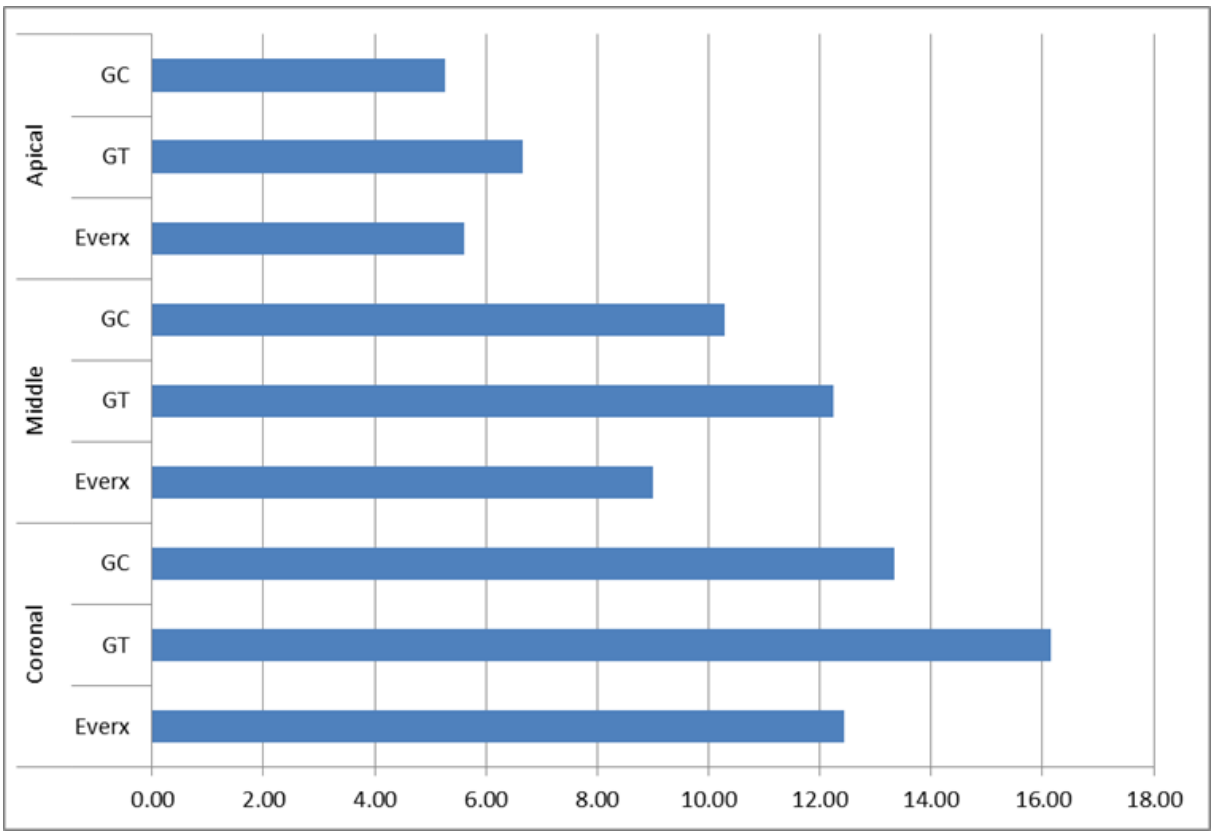
The alternative hypothesis H_1: *at least one of the groups is different*

Results

Mean values of all groups are shown in figure 3.

Based on the result it can be concluded that there are no differences between the mean values of coronal, middle and apical sections between all fiber posts because of P> 0.05. therefore, no evidence to reject the null hypothesis (the mean values are equal); as a result, the posts performed equally in coronal, middle and apical section. For that no need to go through Tukey test to make multiple comparisons. According to Tukey HSD's test in Ever X, there are three ways

Figure 3: The mean values of all three regions for GC, GT, and Ever X.



difference between the regions. In another way, the difference is a significant difference between Coronal and Middle; also the difference is true for Coronal and Apical as well as Middle and Apical. This result is also true for Rebilda GT post. However, in GC post the result of Tukey HSD revealed that the pairs which are responsible for occurring the difference are Coronal and Middle, and Coronal with Apical. While there is no significant difference in mean values between the Middle region and Apical.

Table 1: Push-out bond strength of different Posts materials at different root canal regions

ANOVA test of the coronal region between GT, GC, and Ever x posts.					
	Sum of Squares	df	Mean Square	F	P-Value
Between Groups	75.209	2	37.604	2.679	0.087
Within Groups	378.930	27	14.034		
Total	454.139	29			
ANOVA test of the Middle region between GT, GC and Ever x posts					
	Sum of Squares	df	Mean Square	F	P-Value
Between Groups	53.561	2	26.780	3.259	0.054
Within Groups	221.869	27	8.217		
Total	275.430	29			
ANOVA test of the Apical region between GT, GC and Ever x posts					
	Sum of Squares	df	Mean Square	F	P-Value
Between Groups	10.781	2	5.390	2.842	0.076
Within Groups	51.214	27	1.897		
Total	61.995	29			

Table 2: ANOVA test for push-out bond strength at different root regions within the same material

		Sum of Squares	df	Mean Square	F	P-Value
Ever X	Between Groups	232.568	2.000	116.284	17.945	0.000
	Within Groups	174.959	27.000	6.480		
	Total	407.527	29.000			
Re-bilda GT	Between Groups	453.945	2.000	226.972	29.730	0.000
	Within Groups	206.130	27.000	7.634		
	Total	660.075	29.000			
GC Fiber post	Between Groups	332.835	2.000	166.417	16.585	0.000
	Within Groups	270.924	27.000	10.034		
	Total	603.759	29.000			

Discussion

The push-out bond test has been shown to be more dependable in measuring the bond strength of luted fiber posts because it provides smaller adhesive areas, more uniform stress, distribution on the adhesive interface, few lost specimens during experimentation, low standard deviation values, ease of execution.[10] Other advantages of the push-out bond test for fiber post-bonding include: easy to perform, easy specimen preparation and availability of multiple specimens out of one root.[11,12]

Bond strength of posts showed that the highest values for the coronal region and lowest for the apical region in all posts type, the explanation for this result could be attributed to gradual decrease in the number of the dentinal tubules from the coronal to the apical part of the root thus the reduced infiltration of the adhesive into the tubules and less formation of the resin tags in the apical parts, and because the adhesion is enhanced by penetration of the resin into the tubules, its values are low at the apical third. This coincides with Perdigao et al[13] and Arcangelo et al [14] who stated that the difference in the number of tubules may explain why the strongest adhesion occurred in the most coronal sections where there is a greater number of tubules per square mm, but this result in conflicts with Gaston et al[15] and Foxton et al [16] who stated that the apical bond strength was significantly higher in the apical region because the bond strength is related more to the area of solid dentin than to the tubule density. Gaston et al[15] and Foxton et al[16] prepared that post space without previous endodontic treatment; also, they didn't use any irrigation solution.

Additionally the coronal portion of the canal is the most accessible part of the canal space making it easier to etch and more thoroughly apply the adhesive agent than in deeper area of the canal, besides the residual guttapercha and remnant irrigation fluid which can compromise the polymerization of the resin cement and the formation of the resin tags in the apical portion and hence the low bonding strength values.[17] Also at the middle and apical regions, reduction in curing light transmission could account for a decrease in the polymerization of the luting cement in these regions, thereby accounting for the lower bond strengths achieved by the luting cement in these regions.[14] As well as the type and chemical composition of the dentine bonding agents.[18]

Another factor that may cause reduced dentin bond strengths is the polymerization shrinkage stress created by the resin cement within the long narrow post space. These shrinkage stresses are caused by a high C-factor (ratio of bonded to non-bonded surfaces) of the post space.[19]

Comparison of bond strength among Rebilda GT, GC fiber post and Ever X as post material. The highest bond strength was for the Rebilda GT post although it's not statistically significant its may due to the design of Rebilda GT which have a bundle of posts and this give more surface area for luting and better force distribution. Another factor is using Rebilda DC, which is from the same manufacturer of Rebilda GT.

The smooth surface and loss of fitness for the prefabricated posts reduce their bond strength. This coincides with Bergoli et al [20]. who stated that the fitness is a critical factor in post retention and it should not rely only on the bonding ability of resin cement for post retention and because Rebilda GT post can be fitted in all type of root canals and different canal morphology, so it acts superior to other posts.

As Rebilda GT post has a greater diameter than other posts and can be expanded, so the result of this study coincide with Kremeier et al, [21] and Egilmez et al[22], they stated that as the post diameter increase, the cement thickness decrease, so finally the mean bond strength will increase.

In particular, fiber post-Rebilda GT might enhance the friction level between post and tooth structure when compared with the prefabricated post. The result of this study echoed the finding by Bell et al[23], that demonstrated higher bond strengths of an individually formed post compared to a prefabricated fiber post. Also, the use of accessory fiber posts associated with the main post increases the immediate push-out bond strength to the root canal, which is the closest concept to Rebilda GT system.[24]

To reach maximum physical properties of luting cement between a post and dentin, the conversion rate should be as high as possible.[12] Van et al [25] investigated the possibil-

ity of polymerizing glass fiber– reinforced resin composite material FRC into a post space by determining the depth of light-initiated polymerization of the FRC. The authors concluded that in the longest cylinders, FRC showed a slightly higher degree of conversion compared to resin only, and added that this might be due to the fibers ability to conduct light and because Rebilda GT is bundle post and contain cluster small fiber posts the study of Van et al[25] come along with our study.

In Ever X Posterior group, since no additional cement was used between Ever X Posterior material and dentin, Long, narrow, and deep cavities have high C-factor causing shrinkage stress during polymerization, which might exceed the bond strength.[24] Additionally, the curing light loses too much intensity due to attenuation before reaching the bottom of the cavity, and inadequate polymerization can occur in the deep sections of the cavity.[25] In addition, the light conducts and scatters over the fibers for longer distances and results in relatively deep and wide polymerization. Since the root canal has high C-factor design, Ever X Posterior was selected in the present study instead of post. Ever X Posterior results in a degree of toughness that is equivalent to dentin and provides anisotropic reinforcing effect.[23]

A previous study[26] indicated that the FRC had been claimed to control polymerization shrinkage stress more favorably within the restoration. On this note, the similar bond strength results obtained with Ever X Posterior (instead of post) could be related to its well adaptation and thereby good bonding to the root canal wall.

Conclusion

Within the limitation of the present study, it can be concluded that Rebilda GT post shows good bond strength than GC fiber post and Ever X as post material, but it's statistically nonsignificance. The means bond strength for all posts is higher in the cervical region than the middle and apical third.

Short FRC (Ever X Posterior) represented comparable bonding performance with GC Post and Rebilda GT post when it was used instead of post material.

Conflicts of interest

The author reported no conflict of interests.

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