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Influence of Different Surface Treatments and Type of luting Cement on the Retention of Glass Fiber Posts

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A B S T R A C T

Background and objectives. The restoration of endodontically treated anterior teeth with excessive coronal destruction often requires a post and core system. One of the common treatments of these teeth is by using the glass-fiber posts. Although it offers better retention and stress distribution when used, debonding is still the most common mode of failure for glass fiber posts. Objectives: This study aimed to evaluate the bond strength of different surface treatments of glass fiber post systems using different adhesive systems via push out test. **Methods.** Forty-two extracted human incisors teeth were selected. The coronal aspect of each tooth was sectioned at 2 mm above the level of cement-enamel junction, and the remaining root received root canal therapy. Post spaces were prepared in all specimens to a depth of 10 mm. The teeth were divided randomly into three main groups, each of 14 specimens according to the glass-fiber post surface treatments: group I: control group (untreated glass-fiber posts surfaces), group II: glass-fiber posts subjected to sandblasting surface treatment with50μm aluminum oxide particles, group III: glass-fiber posts subjected to treated with 10% hydrofluoric acid. Each group has been subdivided into two subgroups, each of 7 specimens according to type of cement used as following: subgroup a: posts cemented by rely X Unicem, subgroup b: posts cemented by multilink N cement. Roots were then cut into three sections coronal, middle, and apical. Push-out test was performed in a universal testing machine at a crosshead speed of 1 mm/minute, until the post segment was dis- lodged from the root section. The data were collected and analyzed with three-factorial ANOVA followed by pair-wise Tukey's post-hoc tests ($p \leqslant 0.05$) were performed to detect significance between subgroups. Statistical analysis was performed using SPSS IBM V.22. **Results.** The results showed that the effect of different surface treatment on push out bond strength it was found that air born particles treated group recorded statistically significant ($p < 0.05$) highest mean value followed by nontreated group while acid treated group recorded statistically significant ($p < 0.05$) lowest mean value ,In regarding to the effect of different resin cement on push out bond strength it was found that Rely X Unicem group recorded statistically significant ($P<0.05$) higher bond strength mean value than Multilink group while In regarding to effect of radicular region on push out bond strength Regardless to cement or surface treatment, totally it was found that apical region group recorded statistically significant ($p < 0.05$) highest mean value followed by cervical region group while middle region group recorded statistically significant ($p < 0.05$) lowest mean value. **Conclusions.** This study concluded that Glass fiber reinforced post treated with sandblasting is more retentive than that treated with hydrofluoric acid treatment.,Rely X unicem cement recorded higher in push out bond strength than Multilink resin cement, Apical segment of the root showed the highest push-out bond strength than cervical and middle.

تأثير المعالجات السطحية المختلفة ونوع اللاصق المطلي على قوة الترابط أوتاد الألياف الزجاجية

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المعالجات السطحية

الملخص

الأهداف: هدفت هذه الدراسة إلى تقييم قوة الترابط للمعالجات السطحية المختلفة لأنظمة أوتاد الألياف الزجاجية باستخدام أنظمة لاصقة مختلفة عن طريق اختبار الدفع. **الطُرق:** تم اختيار 42 قواطع أسنان بشرية

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. تم قطع الجانب الإكليلي لكل سن عند 2 مم فوق مستوى تقاطع المينا الأسمنتي ، وتلقى الجذر المتبقي علاجًا لقناة الجذر. تم تقسيم الأسنان بشكل عشوائي إلى ثلاث مجموعات رئيسية ، كل منها من 14 عينة وفقًا للمعاملات السطحية للألياف الزجاجية: المجموعة الأولى: المجموعة الضابطة (أسطح أعمدة الألياف الزجاجية غير المعالجة) ، المجموعة الثانية: أوتاد الألياف الزجاجية المعرضة للمعالجة السطحية بالسفع الرملي مع 50 ميكرومتر من جزيئات أكسيد الألومنيوم ، المجموعة الثالثة: أعمدة من الألياف الزجاجية تتعرض للمعالجة بـ 10٪ حمض الهيدروفلوريك. تم تقسيم كل مجموعة إلى مجموعتين فرعيتين ، كل واحدة من 7 عينات وفقًا لنوع الأصق المستخدم على النحو التالي:: المجموعة الفرعية أ Rely X Unicem المجموعة الفرعية ب ، التي تم تدعيمها بالاعتماد الأصقN: multilink ثم تم تقطيع الجذور إلى ثلاثة أقسام إكليلية ووسطى وقممي. تم إجراء اختبار الدفع في آلة اختبار عالمية بسرعة عرضية تبلغ 1 مم / دقيقة ، حتى تم إزالة الجزء اللاحق من قسم الجذر. تم جمع البيانات و تم إجراء التحاليل الإحصائي. **الاستنتاجات.** خلصت هذه الدراسة إلى أن الدعامة المقواة بالألياف الزجاجية والتي تمت معالجتها بالسفع الرملي هي أكثر تحفظًا من تلك المعالجة بحمض الهيدروفلوريك. وسجل Rely X unicem الأسمنت أعلى في قوة رابطة الدفع من الأصق N: multilink ، وأظهر الجزء القمي من الجذر أعلي قوة الرابطة من عنق الرحم والوسط.

السفع الرملي
الأسمنت الراتينج
دفع قوة الرابطة

Introduction

Endodontically treated teeth may be damaged by decay, excessive wear, or previous restorations, resulting in a lack of coronal tooth structure. The restoration of these teeth may require the placement of a post to ensure adequate retention of a core foundation [1]. Posts also help supporting fixed partial dentures, where they dissipate and absorb forces during mastication, in a way that avoids damage to the root and the cementing film [2].

Nowadays, demand for esthetic restorations has risen considerably; thus, nonmetal esthetic posts made of either high-strength ceramics or reinforced resins, such as fiber-reinforced resin posts, have become more and more popular. Important characteristics of fiber-reinforced posts involve a modulus of elasticity similar to dentin and their ability to be cemented by an adhesive technique[3].

Another characteristic feature of glass-fiber post is that they can easily be removed from canals when the endodontically treated tooth has to be retreated[4]. Therefore, an important issue is to improve the retention of glass-fiber posts. Many studies directed their efforts trying to provide the best retention of these posts through different surface treatments and luting cements [5,6,7,8].In an attempt to provide better retention of fiberglass posts, various surface treatment techniques have been suggested, such as cleaning the post surface with alcohol, conditioning with phosphoric or hydrofluoric acid, sandblasting with aluminum oxide, silicatization, or applying hydrogen peroxide, silane or a hydrophobic adhesive (unfilled resin) on the surface[8,9]. Airborn-particle abrasion of the surface of the post can improve the retention of glass-fiber post because it increases surface area, and enhances mechanical interlocking between the cement and roughened surface of the post[5]. Also the retention of fiber posts in the roots depends on the bond strength between the post material and a resin luting agent, as well as the bond strength between the resin luting agent and post space dentin[10,11].Selecting an appropriate adhesive and luting procedure for bonding posts to root dentin is an important challenge. Therefore, the aim of the present study was to evaluate the bond strength of different surface treatments of glass fiber posts using different adhesive systems via push out test.

Methods

A. Teeth selection:

In this in vitro study, forty-two extracted single rooted maxillary anterior teeth were selected. Teeth were cleaned and stored in a saline solution. The saline solution was renewed every 5 days till the beginning of the study. The selected teeth were sound, caries-free. With average root length more than 14 mm were selected, so that, this length was chosen to accommodate 3-4 mm of gutta-percha sealing while providing 10 mm for the post. The crowns were sectioned perpendicular to the long axis of the tooth, at 2 mm above the level of cement-enamel junction from labial side, using diamond disc (*Fway Industrial CO, china*) under copious water irrigation.

B. Endodontic Procedures:

A single operator prepared all the teeth. The roots were subjected to endodontic treatment with the ProTaper Universal system (DentsplyMaillefer, Ballaigues, Switzerland), using a hand-held rotary system at low speed (X-smart – Dentsply). The working length was determined visually at 1 mm short of the root apex. The cervical and middle thirds of the roots were initially prepared using the S1, SX and S2 instruments. Then, S1, S2, F1, F2, and F3 files were used in this sequence along the working length (WL), until the instrument no longer provided resistance inside the root canal. The root canals were irrigated with 3 ml of 2% sodium hypochlorite solution before each change of instrument. The final irrigation was done with 2ml 17% EDTA for 3 min, followed irrigation with 2 ml of distilled water. Canals were dried using absorbent paper points followed by lateral compaction obturation technique using gutta percha points size F3 (Meta Biomed Co., Korea) and a resin-based root canal sealer (AH plus, Dentsply Maillefer).

C. Post hole preparation:

Gates-glidden drills size 2, 3 and 4 were used respectively to depth of 10mm inside the prepared root space. A rubber stopper to standardize the post length was attached to the gates glidden, leaving 3-4 mm of gutta-percha apically.

D.Post Surface Treatment and Cementing

D.1.Surface treatment:

After preparation, the roots were randomly divided into the following three groups (n=14), according to the surface treatment of the fiberglass post. Group I: Control group, fourteen fiber post were not subjected to surface treatment. Group II: fourteen post were sandblasted with 50 µm aluminum oxide at 1 bar from distance of 2.5cm and time 10 seconds. Group III: fourteen posts were treated by 10% hydrofluoric acid gel (Condac Porcelana, FGM) applied over the post surface for 1 min followed by rising and drying.

D.2.Post cementation

Before cementation of the post, the post-holes were rinsed with sodium hypochlorite and then washed and air dried before cementation and with paper points. Each group has been subdivided into two subgroups, each of 7 specimens according to type of cement used as following: subgroup **a**: posts cemented by rely X Unicem, subgroup **b**: posts cemented by multilink N cement.

D.2.A Cementation of post using RelyX *Unicem* Cement:

RelyX Unicem cement was used for cementation as recommended by manufacturer. it is a self-adhesive, dual cure, auto mixing resin cement eliminates the need for etching and bonding, thus reducing both sensitivity of technique and chair-side time. Seat the post immediately into respective canal after filled canal by cement. Twist slightly and apply moderate pressure to hold in position while removing excess cement with appropriate instruments or a cotton pellet. Light cure cement for 40 seconds or allow to self-cure for 5 minutes from start of mix.

D.2.B Cementation of post using Multilink N cement:
Multilink N cement by mixing Multilink N Primer A and Primer B were applied on post; the syringe of cement was prepared for use by examining the level of cement base and catalyst first in the two orifice of the syringe to ensure even flow of both base and catalyst. The mixing tip with intra-oral tip was attached to the syringe; the cement was gently dispensed into prepared canal, with help of intra-oral tips inserted into the canals. The post was firmly and carefully placed into the canal under finger pressure and follow manufacture recommendation for setting time of material, excess cement was removed with a sharp explorer.

II.H. Specimen preparation for testing:
Seven specimens of each subgroup were prepared for the push-out test. The root of each tooth was sectioned horizontally and perpendicular to the long axis of the root starting from 2mm below the cement-enamel junction a 2mm thickness slices. In this manner; from each root, three post/dentin sections (coronal, middle, and apical) were obtained Figure 1. The cutting of specimen was performed with a disc mounted on a lathe cut machine, under copious amount of water coolant. Each sectioned root provided three samples of 2mm thickness section with the luted post in the center. The most apical 3-4 mm of root was discarded. These sectioned were namely: cervical, middle and apical ones.

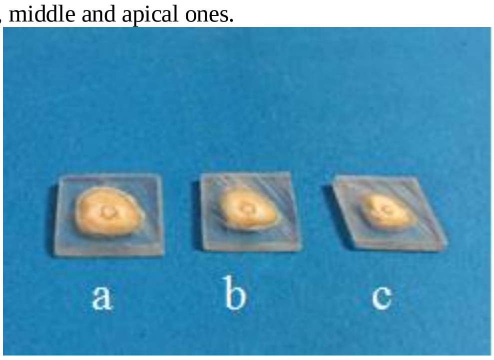

Figure 1: (a) Coronal, (b)middle and (c)apical specimens

Push out Bond Strength:

Test procedure

After mounting in custom made loading fixture, each specimen was subjected to the push-out test via a universal testing machine (Model LRX-plus; Lloyd Instruments Ltd., Fareham, UK) with a load cell of 5kN, at a crosshead speed of 1 mm/minute, using a pin (diameter, 1.0 mm) on the center of the apical aspect of the post surface in an apical-coronal direction, without stressing the surrounding post space walls. The peak force (N) required to extrude the post from the root slice was recorded. To express the bond strength in MPa, the load at failure (N) was divided by the area of the bonded interface, which was calculated with the following formula

Bond = F/A

The adhesion surface area (A) for each section was calculated as:

(π r1+π r2)L, and the value of L was calculated as the square root of $(r1-r2)^2+h^2$, where π was the constant 3.14, r1 was the coronal post radius, r2 was the apical post radius, and h was the thickness of the slice in millimeters.

three-factorial ANOVA followed by pair-wise Tukey's post-hoc tests were performed to detect significance between subgroups. Statistical analysis was performed using SPSS IBM V.22. P values ≤ 0.05 are considered to be statistically significant in all tests.

Results :In regarding to the effect of different surface treatment on push out bond strength it was found that air porn particles treated group recorded statistically significant ($p < 0.05$) highest mean value followed by ***nontreated*** group while ***acid*** treated group recorded statistically significant ($p < 0.05$) lowest mean value as indicated by three-factorial ANOVA followed by pair-wise Tukey's post-hoc test **Table 1 and figure 1**

Table 1: Comparison of total push out bond strength mean values of *surface treatment*

Variable		*Mean ± SD*	*Tukey's rank*	*Statistics*
	Control (non-treated)	4.40±0.50	B	*P* value
Surface treatment	*(+) hydrofluoric acid*	3.60 ±0.46	C	<0.0001*
	(+) air porn particles	5.01 ±1.59	A	

Different letter indicating significance (p<0.05) *; significant (p<0.05)

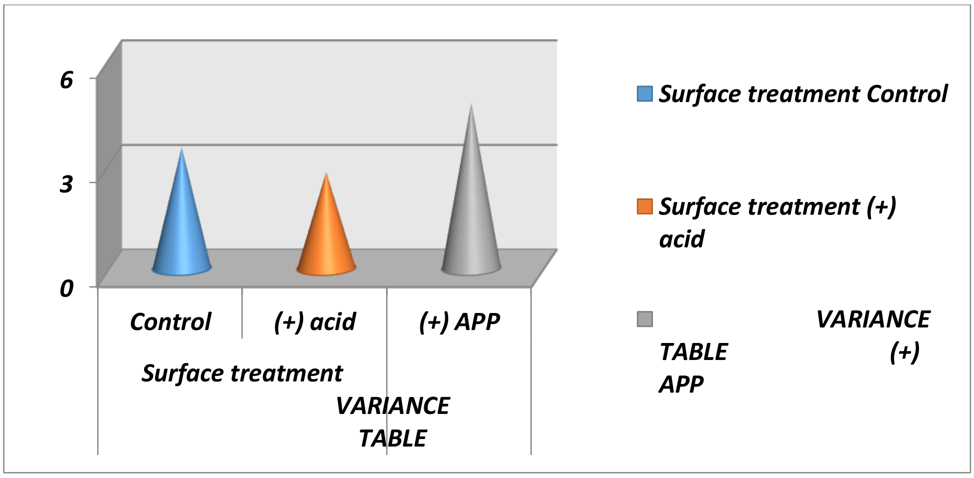

Figure 1:A column chart of total push out bond strength mean values of *surface treatment.*

In regarding to the effect of different resin cement on push out bond strength it was found that ***Rely X Unicem group*** recorded statistically significant (P<0.05) higher bond strength mean value than ***Multilink group*** as indicated by three-factorial ANOVA followed by pair-wise Tukey's post-hoc tests. Table 2 and figure 2

Table 2:Comparison between total push out bond strength results of resin cement

Variable		Mean	SD	Tukey's rank	Statistics (P value)
Resin cement	***Multilink***	3.09898	0.133422	B	0.0014 *
	Rely X unicem	4.12232	1.300099	A	

Different letter in the same column indicating statistically significant difference (p< 0.05)*; significant (p< 0.05)ns; non-significant (p>0.05)

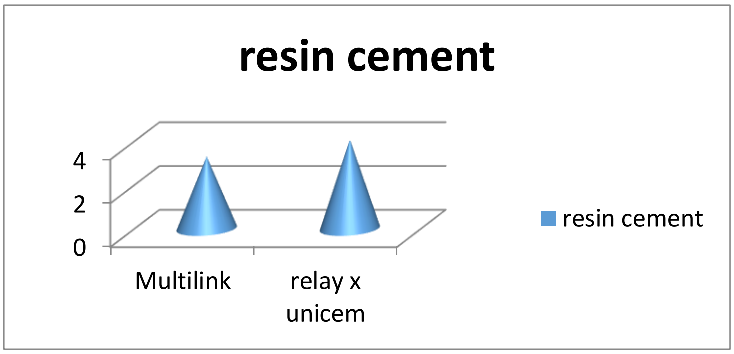

Figure 2:A column chart of total push bond strength mean values as function of *resin cement.*

In regarding to effect of radicular region on push out bond strength Regardless to cement or surface treatment, totally it was found that ***apical region*** group recorded statistically significant (p < 0.05) highest mean value followed by ***cervical region*** group while ***middle region*** group recorded statistically significant (p < 0.05) lowest mean value as indicated by multi-factorial ANOVA. Pair-wise Tukey's post-hoc test showed non-significant (p>0.05) difference between (***Cervical and middle)*** and (***Cervical and apical) region*** groups. **Table 3 and figure 3**

Table 3:Comparison of total push out bond strength mean values of *radicular region*

Variable		Mean ± SD	*Tukey's rank*	Statistics
Radicular region	***Cervical***	2.50±1.5	*AB*	*P* value
	Middle	4.39±1.00	*B*	<0.0001*
	Apical	5.05 ±1.2	*A*	

Different letter indicating significance (p<0.05)*; significant (p<0.05)

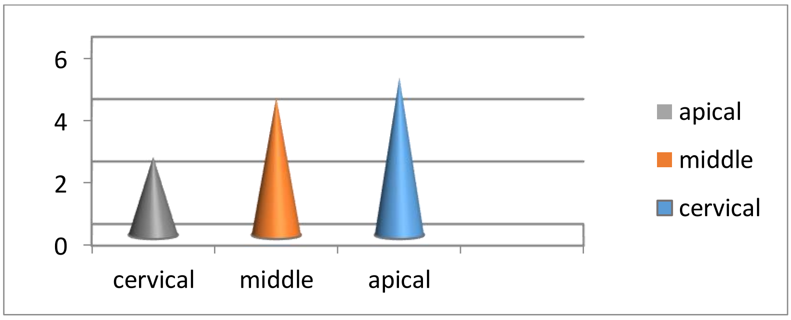

Figure 3:A column chart of total bond strength mean values of radicular region.

Dissuasion: Different strategies have been adopted to enhance the bond strength between the FRC, resin cement, and dentine,one of the strategies to improve the interfacial bond strength consists of the treatment of the FRC surface before bonding [12] .**in current study the results show that the** apical segments recorded the highest mean bond strength values 5.05 ± 1.2MPa compared to cervical 2.50 ± 1.5MPa, and middle root segments 4.39 ± 1.00MPa which was statistically significant effect , the result was agreement with ***Giachetti, L., et al.***[13] . ***Kahnamouei, M.A., et al.***[14] how stated that the bond strength to root dentin seems to be related more to the area of solid dentin in the apical area than to the density of dentinal tubules in the coronal area

The results were disagreement with those of **Kırmalı** et al [15] **Elnaghy et al** [16]***Lopes, G.C.,et al,***[17] ***Taneja, et al,***[18] . reported that bond strength decreased from the coronal to the apical section. This may be explained to apical root dentin is a less favorable bonding because of the presence of areas devoid of tubules, irregular secondary dentin,. another study **Vermelho et al** [19] found that the cervical region have high bond than the apical region. This results show that there are difficulty in penetration of cement in to the deep region.while other **Bonfante et al** [20] that reported that bond is not affected by the root region

The bonding strength values of the current study showed that air abrasion surface treatment significantly improved the bonding strength compared to untreated group while ***10%*** hydrofluoric acid ***ething*** treated group recorded statistically significant (p < 0.05) lowest mean value.

The results were agreement with those of **Tuncdemir et al** [21] *and* ***samira et al,***[22,23] **Elnaghy et al** [24] ***Balbosh, et al*** who explained the sandblasting, creating a mechanical interlocking with the resin cement. mechanical interlock is an important factor on the bonding interface; the clean surface of fiber posts formed by air abrasion can significantly improve the contact angle of the polymer surface and reduce the interfacial energy of the bonding interface[25]

While other studies show the application of air abrasion on the surface of posts may impairing the physical and mechanical properties of posts with plastic deformation and volumetric reduction of the posts ***Zicari, F., et al.***[26] ***Valandro, L.F., et al*** [27]

. In this study the concentration of 9.5 %of HF used by Some authors [28,29] for 20sec, this results in increasing the low bonding strength was explaned by[30,31]. 9.5% hydrofluoric acid resulted in the dissolution of resin matrix at greater depth and also extensively damaged glass fibers within the post, therefore, reduced bond strength values were observed when compared to untreated and other experimental groups

*****Regarding the effect of cement types on push-out bond strength**, results revealed that; Rely X Unicem group recorded statistically significant ($P<0.05$) higher bond strength mean value 4.12232 ± 1.300099 than Multilink group 3.09898 ± 0.133422. This result was agreement with **Liu 2013** [(31)] how show that methacrylated phosphoric ester was added to RelyX Unicem. Each methacrylated phosphoric ester monomer containing double bond which increases the adhesive force to tooth tissue. Unsaturated double bond determines highly reactive and highly crosslinked. After polymerization, highly crosslinked structure maintains good mechanical properties of resin cements.

RelyX Unicem is convenient dual-curing -self-adhesive resin cement, and needs no pre-treatment of porcelain and tooth surface,The dual-cured material presented significantly higher bond strength than the self-cured cement. The probable explanation for the present results is the fact that, only for the dual-cured material the photo-polymerization reaction takes place, which is more effective when compared with the chemical polymerization, ***Braga, R.R., P.F. Cesar, and C.C. Gonzaga*** [(32)] enhancing the conversion of double bond and thus the bond strength to the post. In corroboration,***Goracci, C., et al*** [(33)] reported lower bond strength for self-cured compared with dual-cured materials.

The results were not agreement with those of ***Behr, M et al*** [(34)]who revealed the self-activating system showed a more uniform resin tag and resin dentin inter-diffusion zone formation along root canal walls than dual-curing system curing, this might be attributed to several factors, one of them is that the type of post employed, the FRC post used in this study is produced by the same manufactures of the self-cure resin cement (multilinkN) which make it a full system pack and more compatible. also the dual cure resin cement (rely x Unicem) is alight polymerized adhesive its bonding strength values is compromised at apical and middle region of the root where the curing light might not reach, while the self-cure cement (multilinkN) is self-cure resin with a light curing option in which the main reaction is chemical and polymerization can be further enhanced achieved by light cure.

Conclusion show that:

1-Glass fiber reinforced post treated with sandblasting is more retentive than that treated with hydrofluoric acid treatment.

2- Glass fiber reinforced post cemented with Rely X unicem cement is higher in push out bond strength value than Multilink resin cement.

3-Apical segment of the root showed the highest push-out bond strength than cervical and middle.

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