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ORIGINAL ARTICLE

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# Effect of different root dentin pretreatment protocols on the bond strength of fiber posts cemented with core buildup material

Efeito de diferentes protocolos de pré tratamento de dentinas radiculares na força de adesão de pinos de fibra cimentados com material de núcleo de preenchimento

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## ABSTRACT

**Objective:** The purpose of the study was to evaluate the push out bond strength of fiber posts -after cementaion with core build up material and dentin pretreatment using different adhesive protocols- in different root regions. **Material and Methods:** 28 endodonticaly treated human premolars were divided into 4 groups. The post spaces were treated with 1 of 4 different dentin bonding protocols: total etch light cured adhesive, solobond m; total etch dual cured adhesive, Excite f DSC; self-etching light cured adhesive, single bond universal; or self-etching dual cured adhesive, futura bond dc. Fiber posts, were luted with dual cured core material. The roots were cut into 2-mm-thick sections, in cervical, middle, and apical regions. Push-out tests were performed with a universal testing machine, and bond strength values (MPa) were calculated. Data were analyzed with 1- and 2-way analysis of variance and Tukey multiple comparison tests (a=.05). Failure modes were examined under stereo microscope. **Results:** The highest mean bond strength values were obtained for self-etch dual cured adhesive, (9.69 MPa). The Total etch light cured adhesive (2.81 MPa) showed the lowest bond strength. Self-etch light-polymerized and total etch dual-polymerized adhesives provided similar bond strengths (5.37, 5.72 respectively). The regional bond strength values were reduced significantly in apical post space (P<0.01). The most predominant failure type was mixed failure followed by adhesive failure. **Conclusion:** Dentin pretreatment using self-etch dual cured adhesives prior to fiber posts cementation offers a high bond strength. While using total-etch light cured adhesives is not recommended due to the low bonding quality.

## KEYWORDS

Dentin; Bond strength; Fiber posts; Core buildup material; Adhesive protocols; Pretreatment.

## RESUMO

**Objetivo:** O objetivo do estudo foi avaliar a força de adesão dos pinos de fibra após o cimentação com material de núcleo e o pré-tratamento da dentina utilizando diferentes protocolos adesivos em diferentes regiões radiculares. **Material e Métodos:** 28 pré-molares humanos tratados endodonticamente foram divididos em 4 grupos. Os condutos foram tratados com 1 de 4 diferentes protocolos de união à dentina: adesivo fotopolimerizável total, solobond m; adesivo de polimerização dual de condicionamento total, Excite f DSC; adesivo fotopolimerizável autocondicionante, Single Bond universal; ou adesivo de dupla curado autocondicionante, futura bond dc. Núcleos de fibra, foram cimentados com material resinoso e polimerizados. As raízes foram cortadas em seções de 2 mm de espessura, nas regiões cervical, média e apical. Testes de push-out foram realizados com uma máquina de testes universal, e os valores de resistência de união (MPa) foram calculados. Os dados foram analisados com análise de variância de 1 e 2 fatores e testes de comparação múltipla de Tukey (a = 0,05). Modos de falha foram examinados sob estéreo-microscópio. **Resultados:** Os valores médios mais elevados de resistência adesiva foram obtidos para o adesivo dual autocondicionante (9,69 MPa). O adesivo fotopolimerizável Total etch (2,81 MPa) apresentou a menor resistência de união. Os adesivos autocondicionantes fotopolimerizáveis e os de condicionamento tal duais, proporcionaram forças de adesão semelhantes (5,37, 5,72, respectivamente). Os valores de força de união regional foram significativamente reduzidos na região apical (P <0,01). O tipo de falha mais predominante foi falha mista seguida de falha adesiva. **Conclusão:** O pré-tratamento com dentina utilizando adesivos duais autocondicionantes antes da cimentação dos pinos de fibra oferece uma alta resistência de união. Enquanto que os adesivos de condicionamento total fotopolimerizáveis não sforam recomendados devido à baixa qualidade da adesão proporcionada.

## PALAVRAS-CHAVE

Dentina; Resistência de união; Núcleos de fibra; Protocolos adesivos; Pré-tratamento.

## INTRODUCTION

Various luting agents and corresponding adhesive systems have been proposed for bonding fiber posts to root canal dentin. These materials can be light polymerized or dual cured. And they include conventional resin cement which require dentin pretreatment with an adhesive and self-adhesive resin cement that requires no dentin pretreatment and has a dual cure mechanism [1].

Dual-cure resin composite core materials have been introduced for the placement of fiber posts in post spaces because a resin composite has a modulus of elasticity close to that of dentin and fiber posts, and better mechanical properties than those of a resin cement [2]. A study revealed significantly higher bond strength when luting the fiber post with dual-cure core build-up materials than with resin cements [3].

In addition current developments tend to adhesively restore the weakened endodontically treated teeth with fiber post and composite core in a one-stage core-and-post procedure [4], whereas core build-up will immediately follow post cementation using the same composite material (core-and-post materials). Such a procedure could reduce the technique sensitivity, hazards of possible incompatibility of different composites (interface between cement and core material) and the time necessary to complete the core-and-post treatment procedure [4].

The most common failure that occurs with fiber posts is debonding at the adhesive resin-dentin interface due to difficulties regarding dentin hybridization [5]. Studies have shown that hybridization of dentin is affected by modifications in the dentinal substrate caused by irrigants used [5,6], obstruction of the dentinal tubules during instrumentation, preparation of post space [7] and type of adhesive system used [7], and the limited action of light-curing units that can be achieved in deep canals [8].

The histological characteristics of dentin in endodontically treated canal walls, the properties of the different materials available for bonding in addition to the polymerization stress of resin cement in root canals with unfavorable cavity configuration factors, and the chemical and physical properties of the posts are all variables that can possibly influence the quality of adhesion at the post-cement–adhesive–dentin interfaces [9].

In addition , the quality of adhesion to the root dentin is affected by density and orientation of the dentin tubules at the different levels of root canal walls [10] and the accessibility of coronal, middle, and apical thirds of the root canal during handling of the materials [11].

Over the years, the trend has been to develop adhesive systems that are “simplified” or, in other words, that involve fewer steps with less procedure time [12]. Some of these adhesives shows a certain degree of incompatibility when used with chemical or dual cured adhesives. due to their acidic monomers content which can react with the basic catalytic components (aromatic tertiary amines) of self/dual-polymerizing composites and interfere with their polymerization [13].

Self-etching adhesives are much more acidic in nature and tend to be more susceptible to this material incom7patibility [13,14].

To improve compatibility with self/dual-polymerizing composite resins, some manufacturers now include an additional activator which buffer the effect of acidic monomers and prevent its reaction with the basic catalytic components (aromatic tertiary amines) of self/dual-polymerizing composites and interfere with their polymerization. Unfortunately, these activators are not always effective [15,16]. This may be due to the dilution of the adhesive resin by the activator which could then negatively affect the formation of the hybrid layer [15,16].

Therefore, selecting an adhesive system that provides reliable and long lasting bonding to root canal dentin remains difficult especially in the apical part of the root, as a certain Incompatibility exists between the light cured bonding agents used for treating the dentin wall before cementation and the materials used for cementation (which are dual cured). And here the question arises whether, the dual cured bonding agents are effective in bridging this incompatibility difference.

The hypothesis of this study is that fiber post cementation with core buildup material has acceptable bond strength in combination with different root dentin adhesive treatments.

The null hypothesis was no difference between different adhesive dentin treatments.

## MATERIALS AND METHODS

This work was approved by the committee of faculty of dentistry Ain Shams University research ethics (FDASU-REC). Twenty-eight single rooted recently extracted lower premolar human teeth were collected. Teeth had average 4-5mm mesiodistal diameter at the cementoenamel junction and 14mm root length. Radiographs were taken to examine root integrity and number of canals present. All teeth used in this study had one canal in each root. Teeth were examined under clinical microscope those with root decay, cracks, resorption or previous endodontic treatment were discarded. The teeth were stored in distilled water at room temperature until the time of use. The crown of each tooth was removed at the cementoenamel junction leaving the 14mm root length, using a low speed diamond disc attached to straight handpiece unde111r copious water irrigation.

Mechanical cleaning and preparation of the canals was done using Revo S, MICROMEGA, FRANCE rotary files size # 20, 25, then the apical preparation was completed manually to master apical file size # 50.

The canals were dried using paper points size # 50 then obturated using cold lateral condensation technique and resin sealer (ADSEAL, META BIOMED Co, Korea). After endodontic treatment, roots were stored in distilled water till next step.

Post space was created leaving 4mm as apical seal. Post space drilling was done with low speed handpiece under copious amount of irrigation with distilled water using the drills supplied by the manufacturer.

In all specimens' glass-fiber reinforced composite posts (dentoclic ivory, ITENA, Paris, France), were used. The materials used for post placement were applied according to manufacturers' instructions.

**Table I -** Sample grouping.

| Cement / Adhesive | Core builup material | |
|---|---|---|
| | Total etch adhesive (T) | Self stch adhesive (S) |
| **Light cured (L)** | LT | LS |
| **Dual cured (D)** | DT | DS |

Total etch light cured adhesive:

Group LT (Solobond m)

The root canal dentin was etched with acid etchant gel, (Meta Etchant, META BIOMED CO, Korea) for 15s, then rinsed with water spray for 30s and the inside of the canal was rinsed with plastic needle to ensure removal of acid etchant in the apical part of the canal. The canal was dried with oil free air for 5s and then by absorbent paper points until paper points came out of the canal dry.

Solobond m was applied inside the root canals using super fine(1mm) micro brush then followed by paper points insertion to remove excess and avoid pooling of the bond then it was light cured from the top of the post space preparation for 10s using a LED light curing unit with output intensity of 1200 mw/cm2 ( Elipar Deep Cure- S 3M ESPE).

Total etch dual cured adhesive:

Group DT (Excite F DSC).

The root canal was etched as mentioned before then Excite F DSC was applied inside the canals, using its small endodontic brush then followed by paper points insertion to remove excess and avoid pooling of the bond then it was light cured for 1s.

Self-etch light cured adhesive:

Group LS (Single bond universal)

Single bond universal adhesive was applied to the root canal dentin using super fine (1mm) micro brush, rubbed for 5s and air dried for 5s. Followed by absorbent paper points to remove excess. Then light cured for 10s using the same light curing unit.

Self-etch dual cured adhesive.

Group DS (Futura bond DC).

futura bond DC single dose was used. The first compartment was pressed to allow mixing of the bond with the activator. Then the second compartment was penetrated by the micro brush. Active application of the adhesive by super fine micro brush for 20s in apicocoronal direction followed by gentle dryness with oil free air for 5s, then by absorbent paper points to remove excess. Then light cured for 10s.

After application of the adhesives LUXA CORE DUAL core buildup material was injected inside the canal using intracanal tip supplied with the product kit, the post was inserted into the canal in a rotation motion using gentle finger pressure allowing excess core buildup material to extrude, then excess material was removed using a micro brush. A load was applied to the post (finger pressure) to ensure complete seating and the cement was light cured for 20s from the outer end of the post.

After the cementation procedures, the roots were stored in distilled water for 2h. Then subjected to Thermocycling, 1000 cycles using Robota automated thermal cycle; BILGE, Turkey.

The roots were sectioned with a diamond disc fixed on the isomet machine (Beuhler's Isomet 4000) using copious water irrigation into three 2.0-mm-thick slabs: coronal, middle and apical. All sectioned samples were stored in 100% humidity until time of testing.

Each root section was examined under stereo microscope (NIKON SMZ1500) at 40X magnification to measure the coronal and apical diameter of fiber posts in order to calculate the bonded surface area according to the following formula "$A=\pi(R+r)\sqrt{(R-r)}"^{2}+(h)^{2}$.

For the push-out test - As recommended by the ISO Technical specification on testing adhesion to tooth structure (ISO No. 11405, 2003) -, the load was applied using a cylindrical tip attached to a universal testing machine, Model 3345; Instron Industrial Products, USA. Each sample was placed with the apical surface facing the metal plunger. The metal plunger was fixed to the testing machine and applied perpendicular to the center of the post until dislodgment occurred. The load was applied in the apical-coronal direction of the specimens at a crosshead speed of 0.5mm/min until failure occurred. After the push-out test, each root slice was examined under stereo microscope at 40X magnification to determine the mode of failure.

Data was collected and statisticaly analyized using IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 22 for Windows. Two way-ANOVA was used to study the effect adhesive scheme and root section on mean Push out bond strength (MPa). Tukey's post-hoc test was used for pair-wise comparison between the means when ANOVA test is significant. One-Way ANOVA was used to compare between the different adhesive schemes, and root sections on mean Push out bond strength (MPa).

## RESULTS

Statistical analysis showed that there was a significant effect on push-out strength of adhesive protocol used ($p \leq 0.001$) and root section location ($p \leq 0.001$). The interactions between the independent variables, adhesive scheme and root section location showed significant effect on the mean push out bond strength.

The results of the 1-way ANOVA for the effect of adhesive dentin pretreatment indicated significant differences between the bonding agents ($P<0.01$). Further analysis with the Tukey post-hoc test revealed that self-etch dual cured (DS) adhesives showed the highest mean bond strength, followed by the total etch dual cured and self-etch light cured which showed non-significant difference while the total etch light cured adhesive showed the lowest mean push out bond strength as shown in table 1.

**Table 2 -** The effect of adhesive dentin pretreatment

| | Mean | SD | P |
|---|---|---|---|
| LT | 2.81[a] | 1.37 | <0.01 |
| LS | 5.37[b] | 3.45 | |
| DS | 9.69[c] | 4.45 | |
| DT | 5.72[b] | 1.61 | |

*means with the same letters are not significantly different at p≤0.05.
LT: Solobond m, LS: Single bond universal, DS: Futura bond dc, DT: Excite f dsc.

**Table 3 -** The effect of root section location

| | Mean | SD | P |
|---|---|---|---|
| Coronal | $9.26^{a}$ | 4.06 | <0.01 |
| middle | $5.274^{b}$ | 2.72 | |
| apical | $3.112^{c}$ | 1.49 | |

*Means with the same letters are not significantly different at p≤0.05
*The superscript letters represent significance between the root sections along columns and the subscript letters represent the significance between different treatments along rows.

There was a significant difference between push out bond strength at different root section location. Where the coronal section showed the highest bond strength while the apical section showed the lowest bond strength as shown in table 2. Interactions between the different adhesive schemes and root section location are represented in table 3,

**Table 4 -** interaction between adhesives dentin pretreatment and root section location

| | Adhesive scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | LT | | LS | | DS | | DT | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Coronal | $3.72^{b}_{a}$ | 1.04 | $10.28^{c}_{b}$ | 1.905 | $14.87^{c}_{c}$ | 1.85 | $7.69^{b}_{b}$ | 0.229 |
| middle | $2.742^{a}_{a}$ | 0.901 | $4.38^{b}_{b}$ | 1.64 | $9.46^{b}_{c}$ | 2.36 | $4.96^{a}_{b}$ | 1.44 |
| apical | $1.44^{a}_{a}$ | 0.28 | $2.033^{a}_{a}$ | 0.584 | $4.37^{a}_{a}$ | 1.29 | $3.54^{a}_{a}$ | 0.81 |

*means with the same letters are not significantly different at p≤0.05.
LT: Solobond m, LS: Single bond universal, DS: Futura bond dc, DT: Excite f dsc
*comparison was done between all groups.

### Failure mode analysis

Failure mode analysis of the experimental groups showed that there was no complete cohesive failure either in post or resin cement. Both mixed and adhesive failures showed the most predominant failure types as describes in table 4 and figures (1 and 2).

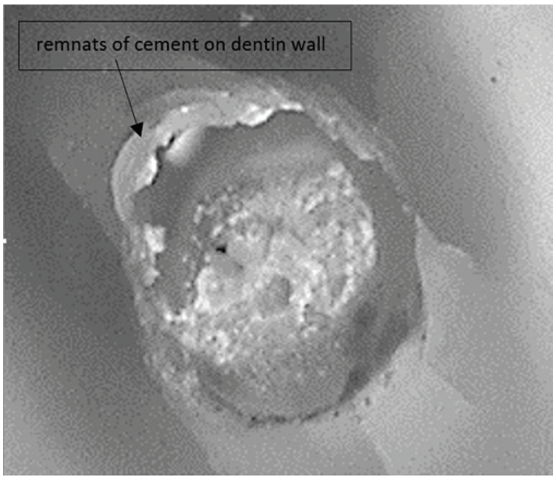


**Figure 1 -** Mixed failure.

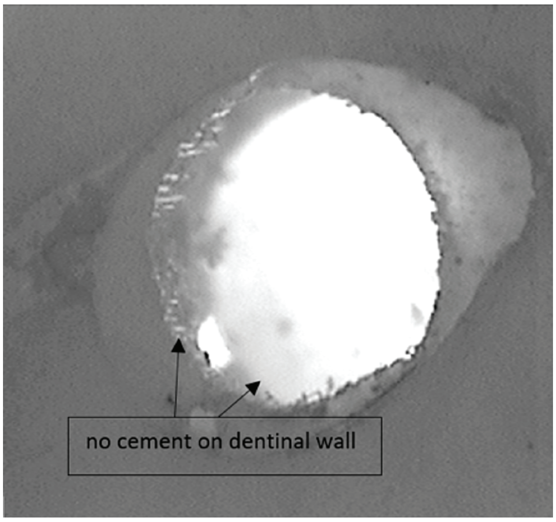


**Figure 2 -** Adhesive failure.

**Table 5 -** percentage of failure type of each experimental group

| | Adhesive | Mixed | Cohesive |
|---|---|---|---|
| LT | 30% | 70% | 0% |
| LS | 25% | 75% | 0% |
| DT | 50% | 50% | 0% |
| DS | 30% | 70% | 0% |

LT: Solobond m , LS: Single bond universal, DS: Futura bond dc, DT: Excite f dsc.

## DISCUSSION

According to the results of this study, the push-out bond strengths of glass fiber posts adhesively luted to root canal dentin was significantly affected by the adhesive dentin pretreatment protocols used.

Total etch light cured adhesives showed the lowest push out bond strength which could be explained by the fact that two steps etch and rinse adhesives are incompatible with self-cured and dual-cured resin cements. This is due to the presence of acid resin monomers in the non-polymerized oxygen inhibited adhesive residual layer, which react with the tertiary amine of the resin cement which was explained by Tay FR, et al in their study in 2003 [14]. Moreover, these adhesives promote a permeable hybrid layer, allowing water diffusion from the dentin and forming water droplets along the adhesive resin-cement interface [17].

On the other hand, self-etch light cured adhesives showed higher bond strength than total etch light cured. Which could be attributed to the elimination of acid etching and rinsing steps in self-etch adhesives and less technique sensitivity. And this was in agreement with the results of Potesta et al. study in 2008 [18]. Also bond strength of self-etch adhesive was significantly more than the etch and rinse adhesive in apical region, this may be due to inadequate rinsing of acid etching gel and improper moisture control that resulted in lower bonding quality in etch and rinse adhesives like the results of Potesta et al. and Akgungor and Akkayan [19] studies.

In the current study the bond strength to post space dentin was highest with dual-cure adhesives especially in the apical region than light-cure adhesives, which may be due to reduced light intensity in the apical and less Degree of Conversion in light-cured adhesives and luting cement [20]. Dual-cure adhesives are less dependent on the light curing unit irradiance [21]. Also these adhesives include additional activator which buffer the effect of acidic monomers and this allows complete polymerization of the dual cured cementation material Thereby, the difference between the bond strength in dual-cure adhesives in different parts of the root canal was less in comparison with light cured ones in this study and the bond strength of dual cured adhesives was more uniform in different parts of the root canal.

In addition, with simplified 2-step etch-and-rinse and 1-step self-etch systems, any unpolymerized acidic monomers present in the oxygen inhibited layer of the polymerized adhesive layer are in direct contact with the composite resin. These acidic monomers can then react with the basic catalytic components (aromatic tertiary amines) of self/dual-polymerizing composites and interfere with their polymerization [13].

In contrast, with 3-step etch-and-rinse and 2-step self-etch adhesive systems, a separate coat of neutral hydrophilic adhesive resin is always layered on the previously etched and primed dentin [22]. As a result, the restorative composite resin does not come into direct contact with the acidic monomer present in the oxygen-inhibited layer. However, the pH of different products varies considerably, even within the same category of bonding agents [22].

It was observed in that study that most predominant type of failure was mixed failure followed by adhesive type of failure at cement-dentin interface as reported by studies done by (Maryam Khoroushi et al. 2014) [23]. The mixed type of failure is an indication of bond strength reinforcement between the fiber post and resin cement and high push out stresses needed to cause fracture of the post and cement layer [24].

Regarding the effect of root section location, the present study revealed that there is significant difference in the push out bond strength in different root sections. Push-out bond strength of the cervical sections was higher than the middle and apical sections, in agreement with the results of Bouillaguet et al. [9] and Mallmann et al. [25] That could be due to better accessibility of the cervical segments, better photo-activation compared with chemical activation alone [26], or tubule orientation and density in the cervical parts of the root canal.

The lower values found in the apical region are reported in literature; this can be explained by the limited light access to the apical region, leading to defective polymerization of the material27. Other factors, such as moisture control in the apical region [28], the presence of residual gutta-percha, and incomplete dentin hybridization [29], may result in deficient sealing of the resin cement-dentin interface in the apical third.

Finally, the current study compared the use of 4 different types of adhesives for dentinal wall pretreatment before the cementation of fiber posts using core build up material to determine the best bonding method for fiber post cementation, as the use of core buildup material for cementation can save time and efforts. The total etches light cured adhesives showed the lowest bond strength due to their technique sensitivity because of the separate etching step, the acid etch may not be completely washed from the apical part of the canal, in ability of the light cure to reach the apical part, and the sort of incompatibility between the light cured adhesive and dual cured cement. The self-etch light cured showed slightly higher bond strength due to its less technique sensitivity than the total etch, but still the bond strength Is low due to its light cure feature. The dual cured adhesives showed a high bond strength than the previous two adhesives as they are not completely dependant on light to achieve complete polymerization, and they are compatible with the dual cured cement, where the self-etch dual cured one is the highest due to absence of separate etching step which may complicate the procedure.

## CONCLUSION

Dentin pretreatment using self-etch dual cured adhesives prior to cementation of fiber posts offers a high push out bond strength. While total-etch light cured adhesives offered a low bond strength. Therefore, the use of total etch light cured adhesives prior to cementation of fiber posts is not recommended.

Therefore, this study concluded that pretreating the dentinal wall with self etch dual cured adhesive prior to cementation of fiber post provides the best results.

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