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Effect of immediate and delayed post space preparation time on bond strength of the self-adhesive and self-etch adhesive cements

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ABSTRACT

Purpose: The purpose of this study was to evaluate the effect of immediate and delayed post space preparation time on the bond strength of self-etch and self-adhesive cements. Methods: The teeth were divided into two experimental groups (n=15) according to different post space preparation time either immediate or delayed. Each group was further divided into three subgroups of five teeth each (n=5), according to the type of cements.
Results: Three-way ANOVA and Tukey's Honestly significant difference test were used to evaluate the results (p=0. 05). With respect to the bond strength of the cements according to root region: push out scores of the coronal part were higher than the apical and middle parts (p<0.05). Conclusion: Delayed push out scores were higher than immediate group for Multilink Automix, according to time. In terms of the adhesive systems individually, the bond strengths of the two self-etch adhesive cement bond strengths (Multilink Automix and Panavia F) were higher than the self-adhesive cement (Maxcem Elite). Delayed or immediate post space preparation time may be important for some cements' bond strength on the other hand it may may not be important for others. Therefore, post space preparation time should be determined according to cement type.

KEYWORDS

Bond-strength;
Post space preparation time;
Root region;
Self adhesives;
Self-etch adhesives.

INTRODUCTION

Endodontic treatment and post systems are used to achieve maintenance of the teeth in the mouth. Endodontic posts are required when there is inadequate coronal tooth structure (especially 50% or more) after completion of the root canal treatment[1]. Demands for aesthetic, posts have led to the development of metal-free post systems particularly usage of translucent fiber posts[2]. In addition, Fiber Reinforced Composite (FRC) posts are preferred to metal posts because of the similarity between the modulus of elasticity of the restorative material and tooth structure, and because they minimize the root fractures[3].

Some clinical studies have pointed out that insufficient bonding performance of fiber posts may result in clinical failure[4,5]. Post retained crowns commonly fail due to a loss of retention[6]. Therefore, root canal posts should have enough bond strength to avoid displacement during function[7]. Various luting agents have been proposed for bonding FRC posts to root canal dentin. Proper selection of the adhesive system influences the success of the posts[8,9]. Recently-developed self adhesive resin cements feature have a new monomer filler, and initiation technology[10]. This material is intended to combine the favorable qualities of the conventional cements with those of the resin cements[11]. Application steps are reduced by eliminating the procedure to pretreat the dentin[12-14]. The manufacturer purports that organic matrix consists of newly-developed phosphoric acid methacrylates. The adhesive mechanism is based on the chemical reaction between hydroxyapatite crystals of the tooth and phosphoric acid monomers[15].

The success of adhesive cementation depends on the interaction between the adhesive system and the root dentin, on the resin cement type and on the post[16]. The post space preparation time may also influence the bond strength values of the bond strength between the root dentin and post. Posts can be placed after settings of the canal sealer, or immediately after the canal treatment[17]. There is a conflict of opinion among authors with regard to the retention of fiber posts cemented at different time intervals[18].

There is little information available regarding the push-out bond strength of self-adhesive cements and post space preparation time in the literature.

The aims of this study were (i) to assess the bonding effectiveness of self-adhesive and self-etch cements: and (ii) to investigate the bonding effectiveness of these luting agents according to immediate and delayed post space preparation time and root region. The hypothesis tested in this study was that there were differences in bonding effectiveness between self-etch and self-adhesive luting agents, and no differences in post space preparation time for all groups.

MATERIAL AND METHODS

Thirty incisors which were extracted for periodontal problems were cleaned by removing any calculus and soft tissues residual and stored in physiological saline solution for no more than 30 days. The crowns were removed from each tooth by sectioning the roots 1mm above the cemento-enamel junction with a high speed diamond saw (Brasseler GmbH, Lemgo, Germany) under water spray. Those teeth with distinctly oval root canals were excluded to have similar cement thickness in all groups, and thirty teeth were chosen for use. The working length of each root canal was established 1 mm short of the apical foramen with a size 15 K-type file. The canals were prepared with a rotary system (X-Smart, Dentsply, Maillefer, Switzerland). All teeth were instrumented using a set of rotary instrument (Pro Taper, Dentsply, Switzerland) to size F3 (multi tapered #30; finishing file) by the same operator. A 2 ml 2% sodium hypochlorite solution (I-Dent, Rohini, Delhi, India) was used to irrigate the canals at every change of instrument, and 5 ml of the same solution was used for the final irrigation. The root canals were then dried with matching paper points. The prepared canals were filled with gutta percha points (Dentsply, Maillefer, France) and a resin sealer (AH Plus, Dentsply, Konstanz, Germany) using cold lateral compaction technique. The coronal aspect of the gutta percha was removed with a heated probe (Gutta Cut, VDW GmbH, Munich, Germany).

The thirty roots were randomly divided into 2 main experimental groups (immediate and delayed post space preparation) of 15 teeth each, and 3 experimental subgroups of 5 teeth each (Figure 1). The canals were prepared for quartz fiber posts (D.T.: Double Tapered, Light, Bisco Inc, USA). The post spaces were prepared immediately after the canals were filled with gutta percha for the immediate group and after 1 week for the delayed group. The canal sealers were mixed and applied according to the manufacturers' instructions. The root filling was removed with the D.T. Universal Drill as deep as necessary for the post to be inserted to 3/4 of the root length. 3 mm of root canal filling were left in the apical aspect. The post spaces for the largest post size #3 were prepared with the matching drill of the post system. The size #3 posts were luted with one self-adhesive (Maxcem Elite, Kerr, Italia) and two self-etch adhesive (Multilink Automix, Ivoclar, Vivadent, Liechtenstein and Panavia F, Kuraray Inc, Japan).

Excess cement was removed from the coronal part with a scaler. Specimens were stored in %100 humid-

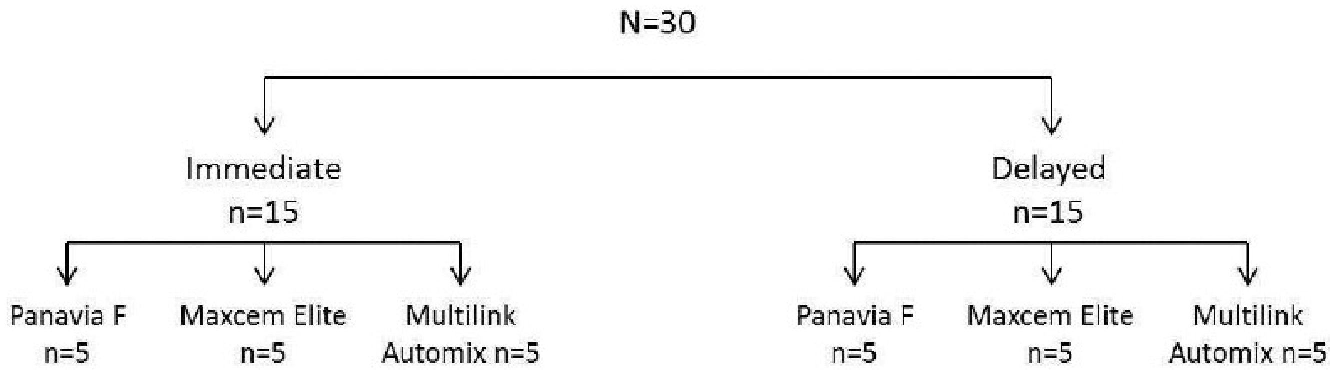

Figure 1 : Shematic view of the groups and subgroups

ity at 37˚C between the phases of the experiment.

Each root was sectioned perpendicular to its long axis to create 1 mm thickness specimens with a 0.3 mm thickness slow-speed diamond saw (Buehler/USA). Six sections (2 coronal, 2 middle, 2 apical) of 1mm thickness were prepared from each tooth (Figure 2). 90 specimens were prepared for each group and 30 specimens were prepared for each subgroup. Their push-out bond strength was tested using a universal testing machine (AGS-X, Schimadzu Corp., Kyoto, Japan) at a crosshead speed of 1 mm/min until post debonding occurred. The specimens were loaded with a 1 mm diameter cylindrical tip in an apical-coronal direction to push-out the post toward the wider part of the root slice to avoid the taper limitation. The cylindrical tip was positioned to touch only the post (Figure 2). The data were recorded as (N), and to express in MPa, N was divided by the area of the bonded interface, which was calculated with the following formula:

$A=2\pi rh$ ($\pi=3.14$, r is the post radius, and h is the thickness of the specimen in mm).

The failure mode of each debonded specimen after the push-out test was assessed under a stereomicroscope (Leica M165C, Leica Microsystems, Germany) at 40x magnification (Figure 3). The failure modes were classified as (i) between post-dentin failure, (ii) between post-cement failure, (iii) mixed failure both post-cement and post-dentin failure.

A preliminary linear regression analysis showed that the tooth region did not have a significant influence on the measured push-out bond strength. Therefore, the slices were considered as independent within each group. The push-out strength data were first verified using the Shapiro-Wilk test for their normal distribution, and by Levene's test for the homogeneity of variances. A three-way analysis of variance (ANOVA) was subsequently performed with push-out strength as the dependent variable, and post space preparation time, type of adhesive system, and root region as fixed factors. Tukey's test was used for post hoc comparisons (p=0.05).

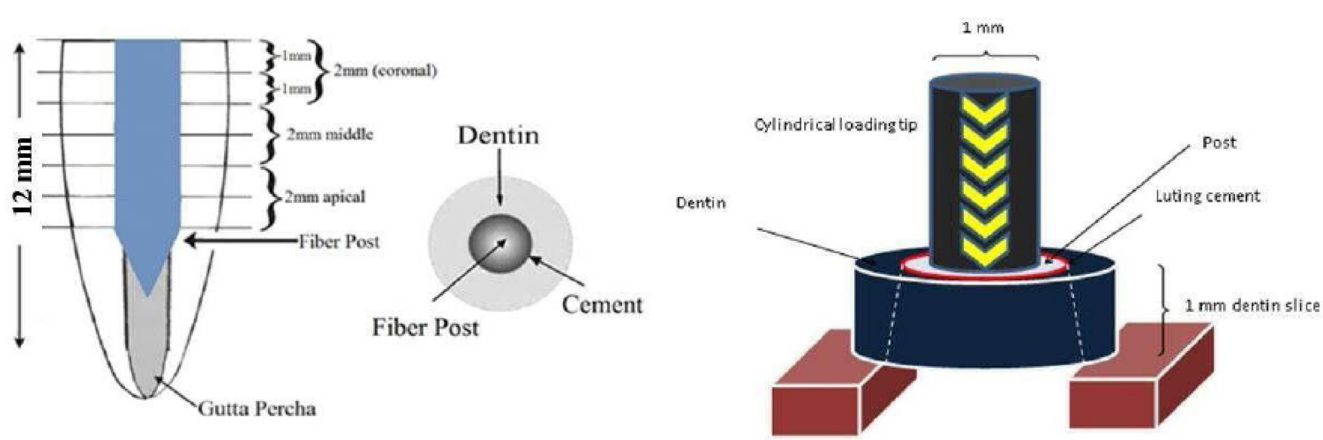

Figure 2 : Shematic view of the tooth section and push-out test

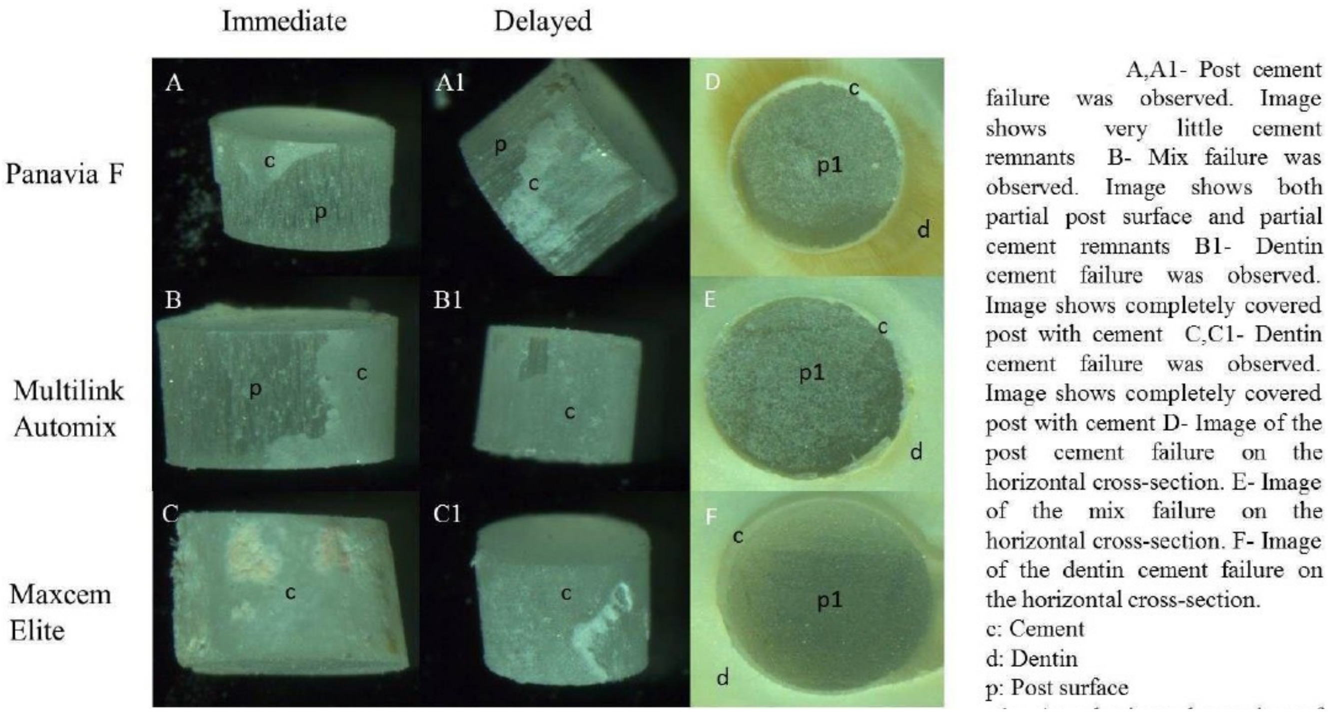

Figure 3 : Push-out failure image of the cements

RESULTS

The three-way ANOVA revealed that all of the factors (type of cement, time, root region) affected the push out bond strength of the fiber post, and the interaction between the type of cement and post space treatment time was significant ($p<0.05$) (TABLE 1).

In terms of the bond strength of the cements according to post space preparation time, only the Multilink Automix delayed push out scores were higher than those for the immediate post space preparation time group ($p<0.05$), and there were no differences for Panavia F and Maxcem Elite ($p>0.05$) (TABLE 2). In terms of the cements, individually the bond strengths of the two self-etch adhesive cements (Multilink Automix and Panavia F) were higher than self-adhesive cement (Maxcem Elite) (P<0.05) (TABLE 3). With regard to the bond strength of the cements according to root region; the push out scores for the coronal part were higher than for the apical and middle section of the root region ($p<0.05$) (TABLE 3).

The fracture patterns of the cements were for Panavaia F; post-cement failure, for Multilink; mixed failure (immediate) and dentin-cement failure (delayed), for Maxcem; dentin-cement failure observed (Figure 3).

TABLE 1 : Three-way analysis of variance (ANOVA) results

Source	Sum of Squares	df	Mean Square	F	P
Type of cement (C)	32,436	2	16,218	3,753	0,026
Time (T)	48,902	1	48,902	11,317	0,001
Root Region (R)	141,719	2	70,859	16,398	0,000
C X T	63,960	2	31,980	7,401	0,001
C X R	8,132	4	2,033	0,470	0,757
T X R	0,308	2	0,154	0,036	0,965
T X P X R	18,359	4	4,590	1,062	0,377
Error	700,023	162	4,321		
Total	4357,254	180			

df, degrees of freedom.

TABLE 2 : Push out bond strength scores (Mean±SD (MPa)) of the cements according to the time.

Cements	Immediate	Delayed	Total
Panavia F	4,55±2,05 a	4,55±1,44 a	4,55±1,75 B
Maxcem Elite	3,50±2,34 a	3,92±2,54 a	3,71±2,43 A
Multilink Automix	3,31±2,73 a	6,02±2,07 b	4,67±2,76 B
Total	3,79±2,42	4,83±2,23	

Small letters show the difference between the post space preparation times; capital letters show the difference between the cements totally and different letters indicate statistically significant differences (Tukey test p<0.05).

TABLE 3 : Push out bond strengths (Mean±SD (MPa) of the region

Cements	Coronal	Middle	Apical
Panavia F	5,43±1,55b	4,18±1,39ab	4,04±2,00a
Maxcem Elite	5,21±1,95b	2,87±1,77a	3,05±2,80a
Multilink Automix	6,03±2,39b	3,75±2,51a	4,21±2,93ab
Total	5,56±1,99 b	3,60±1,99 a	3,77±2,62 a

Coronal part showed higher bond strength than middle and apical part ($p<0.05$). Different letters indicate statistically significant difference (Tukey test $p<0.05$)

DISCUSSION

The results of this study require the partial rejection of the hypothesis, since the bond strength of the self-adhesive cement was lower than the self-etch adhesive system on the other hand the bond strength of Multilink Automix cement was aeffected by the post space preparation time. This may result from the limited ability of self-adhesive cements to diffuse and decalcify the underlying dentin[19,12] and the high viscosity and neutralization effect of the buffering components of the smear layer during setting[12]. The low bond strength measured for the middle and apical root region may depend on the non-uniform adaptation of the luting material, its high viscosity, or its incomplete polymerization, as a result of the diffuculty in accessing canal space[19,20] and also tubule density and diameter of the tubules decreases in the apical direction[21] which may influence the micromechanical bonding mechanism of the adhesive systems.

The DT Light-Post system is a double-taper radiopaque translucent fiber post with unidirectional 60% glass fibers, bound in an epoxy resin matrix. The composition of the fiber post is an important factor that affects the bond strength between the fiber-reinforced post and the resin-based luting agent[22]. Therefore this post system was used for this study.

Many root canal sealers are commercially available on the dental market. AH-Plus is a commonly-used resin-based sealer, and its physical properties are well known[23,24] so this sealer was chosen for this study.

There is no consensus regarding the time interval of post space prepararation, some authors propose immediate preparation[17,25] on the other hand the others suggest delayed preparation[26]. Also many studies have reported that post space preparation time did not aeffect bond strength, either immediately or delayed[25,27]. This discrepancy may be due to differences in the chosen test methods or the setting time of the sealers. In this study bond strength was only different for Multilink Automix cement based on the post space preparation time. Post space preparation time was not important for Maxem and Panavia-F cements. It may arise from the acidic monomers differences to dissolve the dentin. For instance, Multilink Automix contains Phosphonic acid methacrylate but Panavia F contains N-Methacryloyl-5-aminosalicylic acid according to manufacturers. Phosphonic acid methacrylate may be more aeffective on dentin tubulus after setting to canal sealant.

Immediate post space preparation and cementation is less time-consuming[12,13]. On the other hand, concerns regarding the immediate procedure have arisen because of the possible negative effect of the unset sealer on post retention. The removal of the sealer-impregnated dentin from the canal walls during post space preparation is an important factor in post bond strength[14].

Self-adhesive resin cements can not be remove smear layer which is produced during the post space preparation[28-30]. The bonding mechanism of the luting systems to the root canal walls is based on hybridization of the demineralized surface, and on resin tags[8]. Therefore, clean dentin surface with a number of open dentin tubules, which are able to be infiltrated by the adhesive system, is desired while luting fiber posts[1].

The strong clinical performance of self-etch adhesives for luting restorations is described in the literature[8,22]. Its bonding effectiveness was higher than that of the self-adhesive cements used in this study. It can be anticipated that due to the acidic nature of the self-etch adhesives and their permeability dentin tubules cleaned from smear layer, sealing material and infiltrated[31,32]. This finding is consistent with this study.

CONCLUSION

Within the limitations of this in vitro study:

1- The bond strength values for self-etch adhesive cements were higher than for the self-adhesive cement with DT Light post cementation.

2- Push out bond strength values in the coronal section was higher than for the middle and apical sections of the root in all groups.

3- Delayed or immediate post space preparation time may be important for some cements' bond strength (Multilink Automix) on the other hand it may may not be important for others (Multilink Automix and Panavia F). Therefore, post space preparation time should be determined according to cement type.

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