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The effect of etching time duration on the push out strength of self adhesive cement to root dentin

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Abstract--Introduction: Post debonding is one of the most important causes of restoration failure in endodontically treated teeth restored with fiber-post. The weakest connection in post-cement-dentin complex is cement-dentin bonding surface. In this study we evaluated the effect of etching with phosphoric-acid and its duration on push-out strength of self-adhesive resin cement to dentin. Materials and Method: Root canal therapy was done for fifty intact one-canal premolars then the crown was cut from CEJ. Fiber-post space was prepared in the root canal by FGM special drill. The teeth were randomly divided into five groups of ten teeth. Group without any intervention was considered as control-1 and the other groups were prepared for etching. Three groups were etched with 37%phosphoric-acid for 15seconds, 60seconds and 90seconds. In the last group, after preparation, etching protocol wasn't performed which was considered as control-2. In all samples, White post fiber-ost(FGM) size2 was cemented with self-adhesive cement TheraCem (Bisco) and divided into two 4mm pieces and then mounted in acryl. Push-out test was performed by Instron machine for each sample and the shear bond strength was obtained in MPa. Result: Based on the average push-out strength in the experimental groups and statistical tests, it was observed there is a statistically significant difference in the average push-out strength of resin cements to dentin in control-1 group and all other groups. There is a statistically significant difference between

the average push-out strength of resin cements in the 37%phosphoric-acid group for 15seconds and all other groups. There is no statistically significant difference between the average push-out strength of resin cements in the 37%phosphoric-acid group for 60seconds and the 37%phosphoric-acid group for 90seconds. Also, the average strength in the apical and coronal was different only in the control-1 group. Conclusion: Generally, we conclude that pre-etching before the application of self-adhesive cements increases the shear-bond strength.

Keywords--self adhesive resin, fiber post, pre-etching.

Introduction

In recent years, due to aesthetic considerations, the use of tooth-colored posts such as glass fiber and zirconia, which provide sufficient retention for the core, has increased (1). Restoring endodontically treated teeth with fiber post has been popular in recent years (2). Recent systematic studies have shown that fiber posts have a longer lifespan (3 to 7 years) than metal posts. These studies checked features such as root fracture and post debonding from the canal (3). Also, since more attention is paid to aesthetic in dentistry, the use of fiber posts has become routine. In addition to aesthetic benefits, fiber posts are biocompatible and have good physical properties for bonding to teeth and core build-up materials (4).

The use of fiber posts has a special priority due to its modulus of elasticity similar to dentin, the ability to bond to the teeth, uniform distribution of forces and aesthetic in full-ceramic crowns (5). The most common reason for clinical failure in the use of fiber posts in the reconstruction of endodontically treated teeth is the separation of these posts from dentin (6). At present, various cements are used to bond the fiber posts to the dentin. Fiber posts with adhesive cements can form a mechanically integrated structure with dentin. The weakest connection in the post-cement-dentin complex is the adhesion of cement to the dentin surface (7, 8). The bond strength of cement directly affects the bonding quality and the quality of the bond between the post-cement-dentin is the most important factor in fiber post retention. To avoid post debonding and its unfavorable results, it seems necessary to evaluate the cement bonding ability to connect the fiber post to dentin. (9).

To reduce technical sensitivity and avoid debonding, changes have been made in the construction of resin cements and their bonding system (10). An acidic conditioner is usually used during the bonding process, rinsed and air-dried. At this stage, there is a possibility of over-drying of demineralized dentin and collapse of the collagen network. In this case, the resin does not penetrate into the entire thickness of the dentin demineralized area. In case of insufficient rinsing and remaining of acid, the dentin becomes over-etched (11). The self-etch bonding system does not need to dry the bonding surface and the etching and priming stages are integrated in one step, thus, technical sensitivity will be reduced (10, 11). In self-adhesive resin cements, there are no separate etching,

priming and bonding steps. Adhesion is due to the properties of resin molecules integrated into the cement (10).

Despite the ease of cement application, the ability of these cements to form strong bonds to dentin has been questioned from the beginning (10, 11). Laboratory studies with electron microscope showed that when using these cements, collagen demineralization, resin penetration into dentin and complete removal of the smear layer do not occur, which can lead to a decrease in bond strength to dentin (12). Some studies comparing self-adhesive and self-etch resin cements have reported a weaker dentin bond for the first group. On the other hand, in the results of some studies, no significant difference was found between the bond strength of fiber posts that were cemented with different resin cements to dentin (10, 11). At present, due to the inconsistencies in the studies, it is still difficult to select a resin cement with an ideal bond strength to dentin. Therefore, in this study, the effect of etching with phosphoric acid and its duration on the push-out strength of self-adhesive resin cements to dentin was evaluated.

Materials and Method

This study is experimental and has been performed in vitro on 50 one canal premolars. Teeth with similar dimensions and no caries in the root area with a root length of at least 14 mm were selected and teeth that had caries or cracks in the root area were excluded. The teeth were kept in physiologic saline and in each tooth the crown was cut from the CEJ with a diamond disc so that the root remained at least 14 mm long from the CEJ. The canals were prepared chemomechanically with stepback technique, MAF: 35 and MAC:35 for all samples and canal filling was done by lateral compaction method with gutta-percha (Meta, South Korea) and AH26 sealer (Dentsply, Switzerland). After setting of the sealer, using a special drill size 2 (FGM, Brazil), we prepared post necessary space with a length of 10 mm in each sample by removing the gutta-percha in the canal. The special fiber post drill was replaced to prepare each sample to have maximum homology in the samples. The samples were randomly divided into 5 groups of 10 teeth.

For all samples, size 2 Whitepost (FGM, Brazil) with a diameter of 1.2 mm was used. The samples were treated with dual-cure self-adhesive resin cement TheraCem (Bisco, USA) according to the factory order and then light cured for 40 seconds with iLED Plus (Woodpecker, China). Dentin without any intervention will be considered as the control 1 group. In this group, after preparing the canal with special fiber post drill, no intervention was done, including rinsing, drying or etching, and immediately after preparation, the fiber posts were cemented in the canal using resin cement. Other samples were prepared for etching. After using special drill of fiber post, the canal space was rinsed with 10 ml of serum and then dentin etching was performed according to the following protocol. Three groups were etched with 37% phosphoric acid for 15 seconds, 37% phosphoric acid for 60 seconds and 37% phosphoric acid for 90 seconds. The etched samples were rinsed for 10 seconds and then dried with air. The etching protocol was not performed in some samples after preparation and rinsing which will be considered as the control 2 group.

All samples were mounted in acryl by cylindrical plastic molds. After 24 hours, the samples were given a cross section with a 0.20 mm thick diamond disk so that two 4 mm samples were obtained from the part of the root that has a post. The samples were placed in Instron1122 (UNIVERSAL TESTING MACHINE) using a fixture with a diameter of 1 mm so that the tip of the plunger only contacts the post (13). Push-out test was performed on the samples and force was applied from the apical to the coronal of the tooth to each sample until the fiber post debonding from the dentin occurred. Fracture detection (debonding of the post from the dentin) was determined by observing the drop in the curve drawn by Instron software. In this way, the force applied to the tooth gradually increases and this increase in the amount of force can be seen instantly in the diagram in the device software, in the same way that the device records the maximum force applied at the moment of failure (14). By dividing the amount of force on the bonded surface, the shear bond strength was obtained in MPa. Then the mean and standard deviation were calculated and the obtained data were analyzed. The normality of data distribution was determined by SPSS software with Kolmogorov-Smirnov test. We used one way ANOVA analysis to compare the bond strength in the 5 groups mentioned above. Dunnett test (multiple comparison t test) was used to compare the groups pairwise.

Results

The average of the obtained data is shown in Tables 1 and 2. Statistical analysis showed that five groups have a statistically significant difference in terms of shear bond strength. To evaluate the normality of the distribution of the studied variables in the study, Kolmogorov-Smirnov test was used. Significant levels of this test were obtained for the push-out strength of resin cements equal to $P = 0.8$, $P = 0.9$, respectively. Also, this test was not significant for the push-out strength values of resin cements in any of the groups, which indicates that the distribution of all variables is normal. It was observed that the shear bond strength in the control 2 group, 15 seconds of phosphoric acid and 60 seconds of phosphoric acid, respectively, increased significantly compared to the previous group. However, no significant increase was observed in the 90-second phosphoric acid group compared to the 60-second phosphoric acid group. Also, the mean shear bond strength between the apical and coronal was different only in the first control group and no difference was seen in the other groups.

Table 1
Average of the obtained data, coronal dentin

Group-coronal dentin	Count	Mean \pm deviation	P-value
Control 1	10	6/1 \pm 1/2	0/001
Control 2	10	9/1 \pm 0/4	
Phosphoric-acid %37 15 seconds	10	12/5 \pm 1/8	
Phosphoric-acid %37 60 seconds	10	14/01 \pm 1/9	
Phosphoric-acid %37 90 seconds	10	14/28 \pm 1/8	
Total	50	11/16 \pm 3/5	

Table 2
Average of the obtained data, apical dentin

Group-apical dentin	Count	Mean ± deviation	P-value
Control 1	10	4/8±1/1	0/001
Control 2	10	7/8±1/3	
Phosphoric-acid %37 15 seconds	10	11/1±1/8	
Phosphoric-acid %37 60 seconds	10	12/6±1/9	
Phosphoric-acid %37 90 seconds	10	12/58±1/8	
Total	50	9/8±3/4	

Discussion

Today, the use of fiber post has increased due to its desirable features. Many studies have been performed on the preparation of enamel and dentin before the application of self-etch and self-adhesive cements, which had conflicting results on shear strength. There are also various studies available on the use of fiber post with different cements and different preparations. The cements used for fiber posts are conventional cements like glass ionomer, self-etch cements and self-adhesive cements. Since the latter two types are resin cements, they are more commonly used, but for self-adhesive cements, despite their easier application, lower bond strength has been reported in studies (15). Thereby, in this study, we were looking for a way to increase the bond strength of self-adhesive resin cements to dentin. Therefore, the present study has evaluated the effect of etching with phosphoric acid and its duration on the push-out strength of self-adhesive resin cements to dentin in order to help resolve the contradictions in previous studies.

The results of the present study showed that with etching before applying self-adhesive cement shear bond strength has increased in both apical and coronal and also increasing the etching time from 15 to 60 seconds has increased bond strength but there was no statistically significant increase in bond strength from 60 to 90 seconds. Also, in the study of shear bond strength in the apical and coronal, a significant difference was seen only in the control group and no significant difference was seen in the other groups. The strength increase after etching can be due to removal of the smear layer and the greater penetration of resin into the dentin. As the results of our research show, even rinsing without etching has increased the strength, which can be due to the removal of the smear layer, and also in the apical and coronal comparison only in the control 1 group in the coronal part, the bond strength is significantly higher. It could be due to the accumulation of dentin and the remnants of sealer and gutta percha, because as we saw in control 2 group, such a difference was not observed, which could be due to rinsing and removal of residual material.

In a study conducted in 2019 on the effect of etching time and type of material on the shear bond strength of resin cements on worn enamel; They concluded that the bond strength increased in the application of lactic acid for 30 seconds and also phosphoric acid for 15 seconds, which is coordinated with our study. However, there are many differences between enamel and dentin bonding. In enamel we have fewer barriers to bond. While there is no need to worry about the complete removal of etching when etching the enamel surfaces, we have such concerns in the root canal. However, in our study, due to the laboratory nature of the research and the rinsing protocol, this concern has no effect. However, what can be seen from the comparison of these two studies is the increase in shear bond strength with increasing etching time in both, which can be due to the removal of the smear layer. (16)

In a study conducted in 2011 about self-etch adhesives on intact enamel with and without pre-etching; We had both an increase in the penetration of the resin in the enamel and an increase in the shear bond strength, which is in some ways in line with our study (17). In 2014, a study compared the effect of self-adhesive resin cements and resin cements with self-etch bonding system on the amount of DT light fiber post adhesion. Finally, there was no significant difference between the bond strength of the studied cements in different root regions, which in our study was observed only in the first control group and in other groups there was no difference between coronal and apical, which is consistent with our study. (13). Although in our study there was not statistically significant difference between the push out bond strength of the apical and coronal parts, but it should be noted that the bond strength of the coronal part in all samples was more than the apical part and this could be due to insufficient light curing in the apical parts. In this study, we used quartz fiber post, which is opaque and does not transmit light completely. It is recommended to study the difference between quartz and glass fiber posts in this field.

Conclusion

In general, regarding to the limitations of this study, it was concluded that pre-etching before applying self-adhesive cements increases the shear bond strength and the best etching time is 60 seconds. According to this study, there is no difference between 60 and 90 seconds etching, which has already been proven by various studies on composites (18).

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