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Research

Comparison of Push out Bond Strength in Fiber Posts Cemented with 3 Different Cements; Glass Ionomer, Self-etching and Self-Adhesive Resin Cement

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Abstract

Objective: In recent years, due to the increasing of demand for tooth-colored posts, conventional metal posts have switched to various non-metallic posts, including fiber posts.
Resistance to post-fiber displacement depends on their adhesion to the dentin. For fiber post cementation, self-etch, self-adhesive resin and glass ionomer cements are some of cementation materials that commonly used. the aim of this study was to compare the push-out straight between glass ionomer, self-etch and self-adhesive cements in fiber posts.
Method: For this study, 30 extracted central teeth that have a similar anatomical structure and do not have structural problems and caries was used. the root canal for each specimen was prepared and the teeth were randomly divided into 3 groups (self-adhesive, self-etch and glass) (n=10) according to the cementation system. The specimens were then sectioned with dentistry disc (3 incisions in 3 sections of 1and 5 and 8 mm from the cervical region). The samples were then sent to a push-out test in a test machine at a speed of 0.5 mm / min and a load of 5 KN. The experiment was continued until the fiber post was completely separated from the root canal and finally, the push-out bond strength assessment (in MPa) was calculated. To compare the push out bond strength between the three groups, ANOVA statistical test with Tukey supplementary test in SPSS software version 25 was used. Data were reported as mean ± SEM and $P<0.05$ was considered significant.
Results: The amount of push-out bond strength , in contrast to the coronal section, which showed no significant difference between the three groups, in the middle and apical sections, the two groups of self-adhesive and self-etch, had a significant increase compared to ionomer glass. Despite this higher value in the self-adhesive group than the self-etch in the middle and apical sections, there was no significant difference. In all three groups, the push-out bond values of strength in the apical section were significantly higher than the middle section and also, the middle sections were significantly increased compared to the coronal section.
Conclusion: According to this study, it seems that self-adhesive cement has a reliable bond strength for the use of fiber post in endodontically treated teeth and despite its easier clinical application, it is recommended for clinical use. However, this statement needs further study.

Keywords: Self-adhesive • Self-etch • Standard Analytical method • Push-out bond strength • Fiber post

Introduction

Root canal teeth, unlike vital teeth, often need retention for restoration [1-3]. Teeth that have lost more than 50% of the crown need a post inside the canal to maintain and increase the retention of restorations [4]. It should be noted that the main function of the post in the root canal is not only to physically strengthen the remaining tooth structure, but also to increase the retention [5,6]. However, post and core can ensure long-term retention of a restoration [7].

For many years, cast posts and core restorations were the main options for root canal treatment [8]. However, the widespread disadvantages associated with metal posts have led to a reconsideration of these systems.

More precisely, high root fracture and lack of translucency compared to natural teeth are the most important disadvantages of these posts. In addition, corrosive products and the risk of root perforation during post removal have caused doubts about their use [9,10]. Since casting posts may reduce the fracture resistance of the restored tooth, they should only be used in teeth that either do not have a mechanical retainer or its amount is very low [5]. Therefore, new postal systems were developed [11,12]. Fiber posts (FRC) have gained popularity for the restoration of root canal teeth since their introduction in the early 1990s [13].

FRC posts are usually used to provide adequate support and retention for root canal restorations. These posts have the same modulus of elasticity as dentin. Such a characteristic causes a favourable stress distribution and reduces the prevalence of catastrophic fractures (root fracture under the bone surface and linear fracture) [14]. In other words, they can absorb concentrated forces along the root and reduce the possibility of root fractures. A combination of an adhesive band to root canal dentin with a resin build-up core allows the restoration of root canal teeth while preserving the remaining tooth structure [15]. The adhesive band of Fiber Posts can preserve the structures under the tooth layer. Another advantage of Fiber Posts is prosthetic reconstruction of wide root canals [16]. However, a defect in the adhesion between the post and the tooth usually occurs due to de-bonding inside the root canals [17]. Fiber posts are usually attached to root canals by dual-cure resin cements. Ideally, the adhesion of the cement inside the root canal should not create any gaps in the contact surfaces between the post and the cement and the dentin [18]. Both glass ionomers and self-adhesive resin cements are used for fiber post cementation. Self-adhesive resin cements were introduced to the dental market in 2002 [19, 20]. These materials made the cementation process easier and faster with micro mechanical grip and chemical adhesion [21-23]. Self-adhesive resin cements contain multifunctional hydrophilic monomers with phosphoric acid groups that can react with hydroxyapatite and also penetrate the smear layer and create porosity [24,25]. The chemical interaction between acidic monomers and hydroxyapatite ensures the adhesion of self-adhesive resin cements to dentin [26].

The bonding performance of resin cements depends on the quality of the hybrid layer [27,28]. Some factors such as dentin morphology, bonding system and luting cement and its cure qualification, may interfere in the formation of the hybrid layer along the walls of the root canal and affect its retention rate [29-31].

This hybridization is very important in the apical third of the post space due to the difficulty in creating adhesion in this area. Several cements and adhesive approaches have been proposed to connect FRCs to root dentin [32, 33]. Dual polymerization resin cements associated with the previous state of dentin (2 or 3-step wash and etch adhesive systems) have achieved high bond strength [33].

Self-adhesive resin cements have been made recently, and according to the manufacturers, self-adhesive resin cements do not need pre-treatment of the tooth surface, so the self-etch bonding system does not need to dry the bonding surface, and the etching and priming stage is integrated in one step. In this way, technical sensitivity has been reduced.

Recently, Glass Ionomer Cements (GIC) and Modified Resin GIC cements (RMGIC) have been investigated for bonding FRCs [34,35]. The main advantage of GICs and RMGICs is the hygroscopic expansion after water absorption, which neutralizes their initial shrinkage [35,36]. Therefore, the residual water inside dentinal tubules may be used for hygroscopic expansion after water absorption of GICs and RMGICs (for FRC bonding) [37,38]. The resistance to post fiber displacement depends on their adhesion to root dentin [39]. Therefore, the purpose of this study was to compare the amount of push-out straight between glass ionomer cements, resin cements and self-adhesive in fiber posts.

Materials and Methods

For this study, 30 central teeth that were extracted due to periodontal reasons and have a similar anatomical structure and also have no structural problems or caries were collected. The roots were cut to a length of 16 mm (the distance from the apex to the cervical area).

Roots were manually filed with K type files from #15 to #40 to 1 millimetre apex (Mani Japan), and then mechanical preparation continued with 3 different sizes of Glidden Gates (Mani, Japan) (Gates No. 2 to a depth of 10 mm, Gates No. 3 to a depth of 7 mm, Gates No. 4 to a depth of 5 mm) (Figure 1).

Figure 1. Teeth after preparation

Then chemical preparation was done by 3 ml sodium hypochlorite 1% (Nikdarman, Iran) and 1 ml EDTA (Morvabon, Iran). Detergents were used with syringes (Vecto, China) with a capacity of 5 ml and with a gauge of 30 to 2 mm Apex. Then the canals were drying with paper cone (Meta Biomed, Korea) and then filling with resin sealer and Gutta Percha (Meta Biomed, Korea) by lateral compression method. The cervical part of the root was covered with temporary cement and kept in distilled water for 24 hours. Then the roots were kept in an incubator with a temperature of 37°C and 100% humidity for 1 week. The preparation of the post space was done with a #2 size drill (FGM, Brazil) with a length of 10 mm, and then the channel was washed with 10 ml of water and dried with a paper cone.

The teeth were randomly divided into 3 groups of 10 according to the cementation system (Figure 2).

Figure 2. Teeth before cementing

First group: cementation system: self-adhesive resin cements (Bisco, Theracem self-adhesive resin cements USA). Root canals were etched with 37% phosphoric acid for 15 seconds and then washed with water for 30 seconds. At the end, the canal was dried by aspiration and the paper cone. The post surface was cleaned with 95% ethanol and acidified with phosphoric acid for 60 seconds, then washed and dried. Then the cement was manually placed inside the canal with lentulo.

Second group: Cementation system (Masterdent, self-etch resin cement, China): Self-etch resin cement. The surface of the post was cleaned with 95% ethanol and the cement was manually placed inside the root canal with lentulo.

Third group: cementing system: glass inomer (type 1 luting) (GC, Japan). The post surface was also cleaned with 95% ethanol. After mixing the glass according to the manufacturer's instructions, it was manually placed with lentulo.

In all 3 groups, after cementing and placing the post in the specified length, the cement additions were removed with a micro brush immediately. Then, 3 cuts were made by the disk in 3 sections of 1, 5 and 8 mm from the cervical region (Figure 3). Next, the cut surface was cleaned of disk cleaner and other materials with 1200 sandpaper.

Figure 3. Cut sections

Then, the samples were sent to push-out test in an electromechanical testing device (Zwick/Roell Z020, Switzerland) at a speed of 0.5 mm/min and a load of 5 KN. The test continued until the fiber post was completely separated from the root canal and finally, the evaluation of bond strength (in MPa) was calculated (Figure 4).

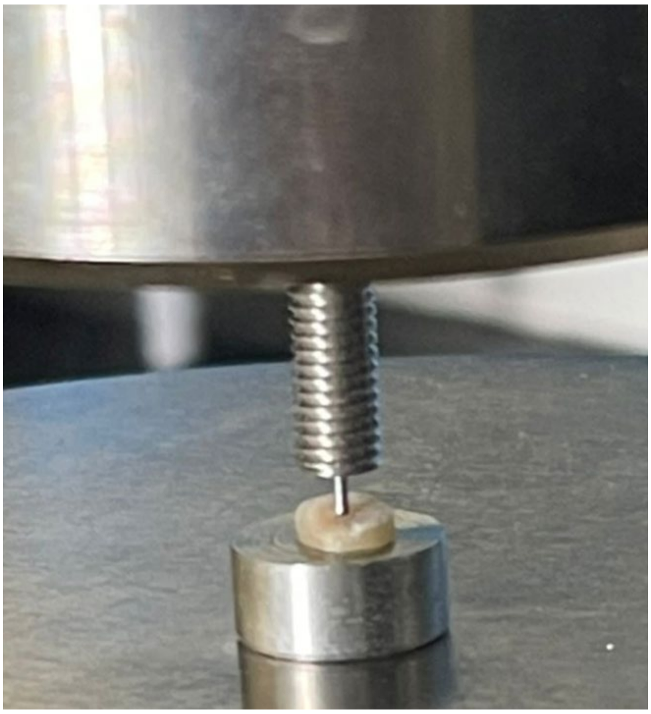

Figure 4. During Push-out test

To compare the amount of push out bond strength between three groups, ANOVA statistical test with Tukey's supplementary test was used in SPSS version 25 software. The data were reported as mean ± SEM and $P < 0.05$ was considered significant.
This is an original study that performed in vitro, which is approved by research ethics Committee of School of Dentistry in Aja University of Medical Science, Iran. (Ethical code: ir.ajaums.rec1400.170)

Results

The results of this study showed that the amount of push-out bond strength compared to the coronal section where no significant difference was observed in the three groups, in the middle and apical sections, the two groups of self-adhesive and self-etch had a significant increase compared to glass ionomer. Despite the fact that this value was higher in the self-adhesive group than in the self-etch, there was no significant difference with each other in the middle and apical sections (Tables 1, 2 and Figure 5).
In all three studied groups, Push-out bond strength values in the apical section significantly increased compared to the middle section and also, the middle sections significantly increased compared to the coronal section (Table 1).

Table 1. Comparison of push-out bond strength values between three types of self-adhesive, self-etch and glass ionomer cements in three coronal, middle and apical sections

	Self-Adhesive	Self-Etch	Glass Inomer	P-value
Coronal	0.23 ± 5/65	0/2 ± 5/80	0/07 ± 5/23	0/789
Middle	0/44 ± 8/44	0/26 ± 7/42	0/14 ± 6/14	04/0*
Apical	0/32 ±9/23	0/47 ± 8/98	0/19 ± 7/01	33/0*
P-value	0/00*	0/00*	0/00*	

Table 2. Push-out bond strength of all studied samples in MPa

	Self- adhesive	Self-Etch	Glass Inomer
Coronal	5/64	6/72	6/08
	4/03	6/67	5/8
	4/76	5/94	4/76
	5/66	3/87	5/65
	7/27	5/97	4/38
	6/54	5/63	4/55
	6/39	6/14	4/81
	4/91	5/46	5/91
	5/42	6/49	4/66
	5/88	5/11	5/7
Middle	9/35	7/55	6/42
	8/95	8/07	5/35
	8/05	7/63	6/67
	8/67	8/28	5/59
	9/19	7/79	6/33
	7/93	7/21	5/86
	8/83	5/56	5/61
	7/53	7/05	6/93
	8/21	7/29	5/95
	7/69	6/77	6/69
Apical	10/02	9/80	7/95
	8/67	8/35	7/55
	9/92	9/35	6/07
	8/28	8/16	7/13
	9/79	9/12	6/47
	8/54	9/07	7/40
	8/94	8/84	6/09
	8/44	8/57	6/62
	10/18	9/61	6/89
	9/52	8/89	7/93

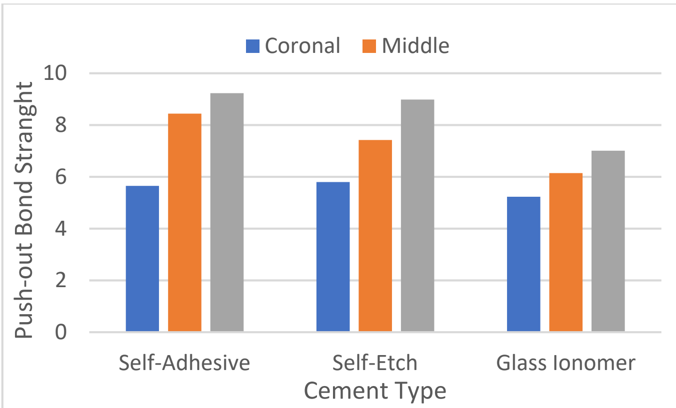

Figure 5. Comparison of push-out bond strength values between three types of self-adhesive, self-etch and glass ionomer cements in three coronal, middle and apical sections

Discussion

The aim of our study was to compare the amount of push-out straight between glass ionomer cements, self-etch resin cements and self-adhesive resin cement in fiber posts. The results of this study showed that the amount of push-out bond strength, unlike the coronal section, where no significant difference was observed in the three groups, in the middle and apical sections, the two groups of self-adhesive and self-etch had a significant increase compared to glass ionomer. Despite the fact that this value was higher in the self-adhesive group than in the self-etch group, there was no significant difference with each other in the middle and apical sections.

Push-out test creates shear stress in the post-cement interface as well as the cement dentin. This test has a better simulation with stresses in clinical conditions than the linear shear test [40].

In addition, a study by Gurachi showed that the push-out test is more efficient and reliable than other methods (microtensile) when measuring the bond strength of fiber posts bonded with adhesive to root canal dentin [41]. For this reason, the push-out test was used in this research. The bond strength of a material to dentin indicates the amount of adhesion that occurs at the interface between them [42, 43].

Root canal bond to dentin is influenced by various factors such as dentin variations , polymerization method , compatibility between resin cement and bonding agent , washing solutions and sealers used for root canal treatment, and Even the method of using adhesive [44-46].

According to the results of the present study, the bond strength in self-adhesive cements was significantly higher than other systems and Theracem showed the highest value among all cements. It is claimed that the adhesion mechanism of the self-adhesive system relies on both micromechanical engagement and chemical reactions between the acidic groups of the monomer and hydroxyapatite [26]. By chelating the calcium ions of hydroxyapatite, acidic groups strengthen the adhesive chemical adhesion [47]. In addition, in order to ensure the neutralization of the initial acidity of this cement, the glass-monomer concept was used, which led to an increase in pH through the reaction between phosphoric acid groups and alkaline fillers. It is claimed that the water formed during this process contributes to the initial hydrophilicity of the cement and, as a result, leads to better compatibility with dentin and humidity resistance. After that, the water is reused by reacting with acidic agents and during the cement reaction with basic ion-releasing fillers. Such a reaction eventually leads to a hydrophobic matrix [26]. Therefore, an ionic bond is formed between cement and dental hydroxyapatite, which has a positive effect on the chemical bond [48]. These reasons may be a good justification for the good performance of self-adhesive cement in the present study.

Glass ionomer cement is mainly bonded to the dentin substrate by a chemical bond between the calcium hydroxyapatite ion and the carboxylate groups formed during the acid-base reaction [49].

Therefore, when analyzing the bond mechanism of self-adhesive resin cement with glass ionomer cement, there are similarities in part of the chemical reactions between hydroxyapatite and carboxyl groups in both. However, the existence of a micro-mechanical, although short, self-adhesive bond can be a good justification for the significant increase in bond strength of this cement with glass ionomer.

In the present study, the samples were kept in distilled water for 24 hours. In a study conducted by Sadek and his colleagues, after 24 hours of immersion in water, a significant increase in push-out bond strength of self-adhesive cement was reported [50].

On the other hand, it is difficult to control humidity after root canal cleaning due to poor visibility. In addition, the narrow channel retains some water due to surface tension, and this makes it difficult to dry the channel space [50]. On the other hand, self-etch systems are usually applied on dry dentin [51].

Therefore, increased humidity inside the root canal may lead to a decrease in the bond strength of self-etch systems, even if the root canals are carefully dried using a paper cone [51]. This can be a good justification for the non-significant increase in the bond strength of self-adhesive cement compared to self-etching. In accordance with our results, a study conducted by Bitter and his colleagues showed that self-adhesive cement has higher push-out bond strength than self-etch resin cements. Nevertheless, some studies comparing self-etch and self-adhesive resin cements have reported a weaker bond with dentin for the second group. On the other hand, in the results of some studies, there was no significant difference between the bond strength of fiber posts that were cemented with different resin cements and dentine [52].

In our study, higher push-out bond strength was obtained in the apical region, especially with self-adhesive resin cements. It seems that self-adhesive systems are less sensitive to dentin depth and dentin tubule density than self-etch and glass ionomer cements. Regarding the tubule density in root dentin, Ferrari and his colleagues reported that the tubule density is the highest in the cervical region and significantly decreases in the middle and apical thirds [44].

Some recent studies have reported that root canal bond strength is not affected by root canal area. However, some studies reported decreased bond strength values in the apical region [41].

The results of our study are consistent with the results of the studies of Bitter and his colleagues, Muniz , Mathias, and Gaston and his colleagues, who reported higher bond strength values in the apical third than in other parts of the root canal [53].

One of the disadvantages that have been raised in the studies regarding self-adhesive cement, it has been shown in the examination with an electron microscope that when using these cements, collagen demineralization, resin penetration into the dentin, and complete removal of the smear layer do not occur, which can lead to a decrease in the bond strength with dentin. But in self-adhesive cements, it seems that the root-dentin bond strength is more related to the dentin area than the density of dentinal tubules [53].

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