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Adhesive capability of total-etch, self-etch, and self-adhesive systems for fiber post cementation

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Abstract. The aim of this study was to analyze whether self-etch and self-adhesive systems are comparable to the total-etch system for fiber post cementation. This experimental laboratory study, which was approved by an ethics committee, was performed using 27 mandibular premolar teeth randomly divided into three groups. Fiber post cementation was done using three different adhesive systems. Specimens were prepared with a thickness of 5 mm, which was measured from the cervical to medial areas of the root, and stored for 24 h in saline solution at room temperature. A push-out test was performed using a universal testing machine (Shimidzu AG-5000E) with a crosshead speed of 0.5 mm/min. The results of one way ANOVA bivariate testing showed that the total-etch and self-etch systems have comparable adhesion capability ($p<0.05$) and that the self-adhesive system has the lowest adhesion capability ($p>0.05$). With easier application, the self-etch system has a comparable adhesion capability to the total-etch system.

1. Introduction

The loss of tooth structure after endodontic treatment causes lack of tooth support for fixed restoration. One of the common post systems used as a solution is the fiber post. Fiber posts have a modulus of elasticity comparable to dentin and provide a better aesthetic than other posts. There are two types of fiber posts on the market: parallel and tapered [1-3]. There were three systems of adhesive resin cement used for fiber post cementation: total-etch (etch and rinse), self-etch, and self-adhesive systems. The total-etch adhesive system was very sensitive in its use because of many factors, such as etching acid concentration, duration of application, and rinsing and drying procedures. The self-etch adhesive system is the next generation of adhesive systems developed, which is easier to apply than the total-etch system. The self-etch adhesive system contains sacidic primer, which acts both as etch and primer, without requiring rinsing and drying procedures. The self-adhesive system was developed after the self-etch system. The self-adhesive system has a very easy application process that does not require any treatment of tooth structures [3-4].

Studies on the adhesive capability of the self-adhesive system have been limited. Other studies have shown contradictory results; some studies concluded that the self-adhesive system has lower adhesive capability than the total-etch system, whereas other studies have concluded that the adhesive capabilities of the two systems were relatively the same. This present study aimed to determine whether the self-etch and self-adhesive systems are comparable to the total-etch system for fiber post cementation [3-4].

2. Materials and Methods

This study was conducted in an experimental laboratory at Dental Material Research Laboratory Faculty of Dentistry Universitas Indonesia. The study was performed on 27 specimens of mandibular premolar teeth, which were divided to three groups randomly. The first group contained specimens that were used with the total-etch system, the second group contained specimens that were used with the self-etch system, and the third group contained specimens that were used with the self-adhesive system.

Freshly extracted mandible first premolar soaked in saline solutin not more than 3 months, and approved by the Faculty of Dentistry, Universitas Indonesia Ethical Institutional Review Board.The coronal portion until *cemento enamel junction*was cut by *diamond dis.* Endodontic treatment was performed on root canal until 1 mm from apical foramen. Root canal was prepared with *Step Back*technique, *Master Apical File* #35 and irrigation using NaOCl 2.5%. Root canal was dried with *air syringe* and *paper point* (DiaDent, Batch no: 022375) Root canal was obturated with *gutta percha* (DiaDent, Batch no: 011209) and *sealer* (Endomethason/Septodont, Batch no: OT B05232AA).The cavity was filled with temporary filling (Tempotec/Septodont, Batch No: 278914with composition*zinc oxide, zinc sulfate, calcium sulfate,* and *excipient*) for 24 hours and soaked in saline solution. Root canal filling was taken out using *gates glidden drill,* leaving *gutta percha*at 3-5 mm from the apical. Root canal was prepared for fiber post using *precisiondrill*length 10 mm, with proper diameter and shape.

The teeth were divided randomly into 3 groups, each groups consisted of 9 teeth. Cementation of fiber post using *total etch, self etch* dan *self adhesive*system. Fiber post used in this study was tapered shaped (FiberKleer/Pentron, Batch no: 4463782) with diameter 1.50 mm. Cementation using *total etch*adhesive system (Cement It/Pentron, Batch no: 4717117): (1) application of etch solution in root canal for 15 seconds, (2) irrigation with aqua bidestilata 10 ml, dried with paper point, (3) application of bonding agent in root canal for 15-20 seconds, (4) application of resin cement in root canal using lentulo and on the fiber post, (5) insertion of the fiber post, polimerization with light for 10 seconds.

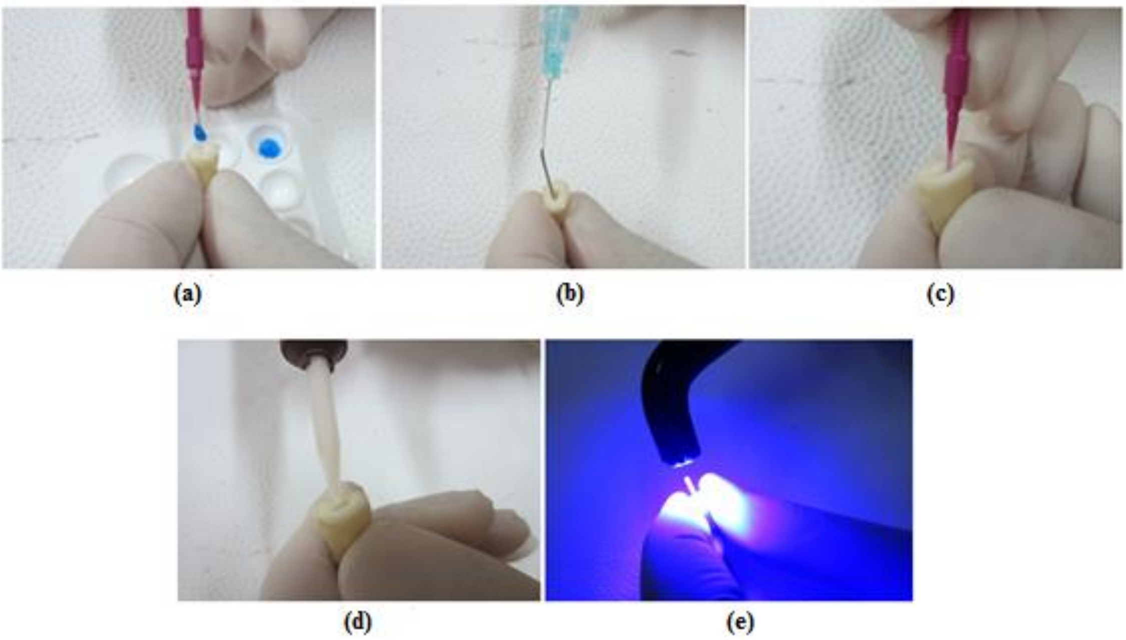

Figure 1. Cementation using *total etch*adhesive system, (a) application of etching solution, (b) irrigation with aquades bidestilata, (c) application of *bonding agent*, (d), resin cement inserted to root canal, (e) polimerize with light

Cementation with *self etch* adhesive system (Multilink N/Ivoclar Vivadent, Batch no: P23243): (1) mixing the primer and bonding agent with proportion 1:1, (2) application to root canal, (3) application of resin cement in root canal using lentulo and on the fiber post, (4) insertion of the fiber post, polimerization with light for 10 seconds.

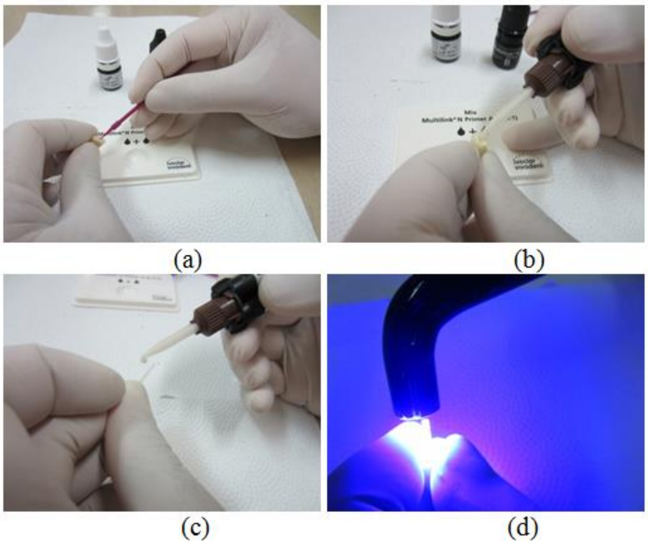

Figure 2. Cementation using *self etch*adhesive system,(a) application *primer* and *bonding agent* to root canal, (b) resin cement inserted to root canal (c) application of resin cement to fiber post, (d) polimerize with light.

Cementation with *selfadhesive* adhesive system(Breeze/Pentron, Batch no:4728204): (1) application of resin cement in root canal using lentulo and on the fiber post, (2) insertion of the fiber post, polimerization with light for 10 seconds.

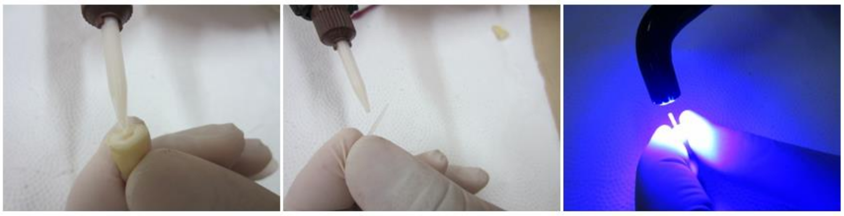

Figure 3. Cementation using *self adhesive* adhesive system, (a) resin cement inserted to root canal, (b) application of resin cement to fiber post, (c) polimerize with light

Teeth root that had been cemented with fiber post planted on *chemical cured polymethyl metacrylate*(Hillon). For each tooth root was counted as one specimen, the part from cervical to medial with the 5 mm thickness. Each specimen with 5 mm thickness, fiber post had 2 types, *parallel* dan *tapered.* Specimens was soaked in saline solution for 24 hours at room temperature. Push out test was performed with *Universal Testing Machine*, with speed 0.5 mm/minute. Plunger with diameter 1 mm was put to fiber post. Push out test was performed from apical to coronal, then the maximum load to took out the fiber was recorded.

A normality test was performed using the Shapiro-Wilk test. Bivariate analysis was then performed with a one-way ANOVA test to evaluate the differences between groups. A post hoc Fisher's least significant difference (LSD) test was used to determine which group(s) accounted for the difference.

3. Results and Discussion

3.1 Results

Data were analyzed to determine the distribution for the variables, means, standard deviations, and maximum and minimum scores (Table1).

Table 1. Distribution of adhesive capability scores for adhesive systems

Adhesive System	N	Mean (MPa)	Standard Deviation	Minimum Score	Maximum Score
Total-etch	*9*	4.6	1.24	2.07	6.49
Self-etch	*9*	4.3	0.29	3.77	4.67
Self-adhesive	*9*	3.4	0.52	2.83	4.60

As shown in Table 1, the mean of the adhesive capability of the self-etch system was in the standard deviation range of the total-etch adhesive system. However, the mean of the adhesive capability of the self-adhesive system was lower than the means of the adhesive capability of the total-etch and self-etch systems, and outside of the standard deviation ranges for these systems. A normality test was performed using the Shapiro-Wilk test (Table 2).

Table 2. Normality test.

		SaphiroWilk		
	Adhesive System	Statistic	Degrees of freedom (Df)	p-value
Adhesive Capability	*Total-etch*	0.943	9	0.617
	Self-etch	0.947	9	0.654
	Self-adhesive	0.887	9	0.186

The result of the normality test using the Shapiro-Wilk test was a probability value, p>0.05, which indicated that the data distribution of the means was normal. Bivariate analysis was then performed with a one-way ANOVA test to evaluate the differences between groups.

The variance test result was 0.062(p>0.05), which indicated no difference in variance between two groups. The one-way ANOVA test result was 0.014, which indicated at least one significant difference between the two groups. A posthoc Fisher's least significant difference (LSD) test was used to determine which group(s) accounted for the difference.

Table 3. Post hoc fisher's LSD

Adhesive System Comparison	Difference of Mean	IK 95%		p-value
		Minimum	Maximum	
Total-etch–-Self-etch	0.30	-0.47	1.08	0.427
Total-etch–Self-adhesive	1.16	0.39	1.94	0.005[a]
Self-etch–Self-adhesive	0.86	0.09	1.64	0.031[a]

[a]statistically significant difference.

A post hoc Fisher's LSD test was performed to compare the adhesive capability between the total-etch and self-adhesive systems, between the total-etch and self-adhesive systems, and between the self-etch and self-adhesive systems. Significant differences were found between the total-etch and the self-adhesive systems and between the self-etch and self-adhesive systems ($p< 0.05$). However, the comparison between the total-etch and self-etch systems showed no significant difference (Table 3).

3.2 Discussion

This study was an experimental laboratory study that aimed to analyze the adhesive capability of total-etch, self-etch, and self-adhesive systems for fiber post cementation. This study used a push-out test method to determine adhesive capability. The push-out test and microtensile test are the most common methods used to test the adhesive capability of adhesive systems for fiber post cementation. Some literature recommends the microtensile test to distribute the load more evenly on small-sized specimens. However, other research indicates that the push-out test is more effective and reliable than the microtensile test because the microtensile test has a higher risk of causing destruction to the specimens [5-8].One of the methods for analyzing the adhesive capability of adhesive systems for fiber post cementation is the push-out test. This study used thicker specimens of mandibular premolar teeth than former studies. The thickness of the specimen in this study was 5 mm in order to better simulate clinical conditions, which are not as well represented using thin specimens. The types of fiber post used were parallel and tapered similar to the root canal anatomy of mandibular first premolars. To standardize the surface treatment, this study used presilanated fiber posts [3-4].

In other studies, the thickness of the specimens used in push-out testing varied between 1.0 mm and 3.0 mm, and there were no strict views on which thickness was better than others. However, thicker specimens or full-post specimens simulate real clinical condition better than thinner specimens. Therefore, for push-out testing, this study used specimens that were thicker, at 5 mm, than other studies. Thicker 5 mm specimens can also be used with two types of posts, parallel and tapered, for clinical root canal treatments of mandibular first premolars. However, this can lead to different load distributions on adhesive surfaces, as marked by lower mean than other studies using thinner specimen [5, 9, 10].The 5 mm specimens were also used to adjust the capacity of the universal testing machine at the Material Research and Development Laboratory at FKG UI Jakarta with a minimal load of 50 KgF. A former study with 2 mm specimens was not successful using a universal testing machine because of a lack of sensitivity and inability to record load data in detail, leading to adhesive capability values that were very low and considered failing. This is another reason this study used specimen that were 5 mm thick.

The specimens used in this study were partial teeth roots. The cervical to medial root parts were used; the medial to apical root parts were not used. This was preferred because, based on results from former studies, the adhesive capability on apical parts is lower than on medial and cervical parts. Other researchers have also had some difficulties using apical parts, such as difficulty accessing adhesive and resin cement, accumulation of debris, difficulty maintaining humidity, and incomplete polymerization with light [8].Analysis of adhesive capability using the push-out test was based on the equation $P = F / (A1 + A2)$,where P is the adhesive capability in Mpa, F is the load in KgF, A1 is the surface bonding area on the parallel post in mm^2,and A2 is the surface bonding area on the tapered post in mm^2. The fiber posts used in this study were a tapered shape, but the posts inserted in the tooth root canal were parallel and tapered. Therefore, the analysis used two methods for parallel and tapered shapes [5].The bonding mechanism of adhesive resin cement and micromechanical bonding properties of dentine depend on the hybrid layer and resin tag. The ability of adhesive systems to form a hybrid layer and resin tag affects the ability to bond to dentine [7].

The total-etch adhesive system involves application of etching solution with a rinsing and drying procedure for priming, application of a bonding agent, and then a cementation procedure with resin cement. In the self-etch system, the etching and priming solution is combined in an acidic primer, and no rinsing and drying procedure is needed. In the self-adhesive system, the etching, priming, bonding, and resin cement are combined in one component, so there is only one application procedure. Because of the more complex application process, the risk of residual etching solution and water was higher using the total-etch system [7, 11].

Statistical analysis showed that the adhesive capability of the total-etch adhesive system was significantly different from the self-adhesive system with better performance. There was an increase of surface bonding area in the root canal after the total-etching procedure. Application of etching solution in the total-etch system can demineralize dentine and promote a deeper hybrid layer and resin tag formation than the self-adhesive system promotes. In the self-adhesive system, a smear layer on the dentine surface is often not cleaned completely, so the hybrid layer and resin tag formation are more superficial [12-13].Statistical analysis showed that the adhesive capability of the total-etch and self-etch systems was not significantly different. This might be because the total-etch system is a more technique-sensitive procedure than the self-etch system, which has a high risk of bonding failure between the cement and dentine.

The total-etch system is a technique-sensitive procedure because of the high risk of overwetting and overdrying during the rinsing and drying procedure after application of etching solution. The application of etching solution removed the smear layer, demineralized hydroxiapatite inorganic matrix, and then exposed collagen fiber and dentine tubuli. Good bonding is formed when monomers in the bonding agent penetrate dentine tubuli and collagen fibers, forminga good hybrid layer and resin tag. If the drying procedure after etching and rinsing is not complete, the dentine would be wet or overwet. On wet dentine, monomer penetration to dentine tubuli and collagen fibers would be easily dissolved because monomers tend to be hydrophilic. The dissolved monomers would cause failure of hybrid layer and resin tag formation, resulting in bonding failure. If the drying procedure after etching and rinsing is excessive with overdrying, the collagen fibers would be fragile and broken with decreased permeability. As a result, monomers in the bonding agent would not penetrate to collagen fibers and dentine tubuli, so hybrid layer and resin tag formation would fail, resulting in bonding failure. This high risk of failure is reflected in the high standard deviation in data from the total-etch system [3, 4, 13, 14].The adhesive capability of the self-etch system in this study showed better capability than the self-adhesive system. This was likely because, in the self-adhesive system, the hybrid layer sometimes formed without the resin tag.

The self-adhesive system has three weaknesses that can lead to bonding failure. The first weakness is in the use of one component that is a combination of components. It is difficult to maintain a stable combination of some chemical components for a long time. The self-adhesive system has a high composition of water that tends to hydrolyze and cause chemical reaction failure, especially during exposure to the high temperatures that occur during the application process. A second weakness of the self-adhesive system is its hydrophilic character that can dissolve adhesive sometime after application and polymerization on dentine. The third weakness in the self-adhesive system is that the acidic composition of the adhesive compound relies on a self-cured and dual-cured polymerization system. Acid can degrade the tertiary aromatic amines that are needed for chemical polymerization. These weaknesses could explain why the self-adhesive system had the lowest adhesive capability among the adhesive systems examined in this study [14-15].

Failures that occur in the push-out test can be due to failures in the adhesion between the resin cement and dentine or between the resin cement and fiber posts, as well as failures in resin cement cohesion or fiber post cohesion. The most common failure is adhesion failure between the resin cement and dentine. In order to minimize this failure, this study used presilanated fiber posts. Presilanated fiber postsprovide a better, more even surface treatment over manual treatments [6-7].In this study, researchers determined that the total-etch system must be performed carefully to prevent bonding failure because this system is very technique-sensitive, particularly during cementation of fiber posts. The operator’s skill in applying the total-etch adhesive system is very important [14]. The other adhesive systems had easier adhesive application procedures, including the self-etch system, which had adhesive capability similar to the total-etch system.

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4. Conclusion

Based on the results of this study, the self-etch system is the best adhesive system for fiber post cementation. The self-etch adhesive application was less technique-sensitive than the total-etch system. The self-adhesive system is the latest generation of adhesive systems, and it had the easiest application process. However, this study showed that the adhesive capability of the self-adhesive system was lower than the total-etch and self-etch systems. Further development of this adhesive system may help resolve its weaknesses. In daily clinical practice, dental professional should understand the strengths and weaknesses of the adhesive systems available for fiber post cementation. This study showed that the self-etch system could be the option of choice because it had good adhesive capability and simple application. Further study can be aimed to analyze where bonding failures occur and to analyze the differences in the bonding mechanisms of the resin cement used in the three different adhesive systems.

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