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Original Article

Bond Strength Evaluation of Two Adhesive Systems in Fiberglass Posts Cementation

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Abstract

Objective: To compare the bond strength of three-step and self-etch adhesive systems with and without prior acid etching on bonding of fiberglass posts in root canals. **Material and Methods:** Experiments were conducted on roots of five upper molars without curvature and sectioned in a cervical-apical direction. With the aid of a high-speed turbine and diamond tips, cylindrical cavities 7 mm in depth and 1.4 mm in diameter were made in the dentine. The roots of the same tooth were used, where the retainers were cemented, thus generating three groups: Group A: Adper Scotchbond Multipurpose Plus (SBMP) + Rely X ARC; Group B: Single Bond Universal (SBU-1) + Rely X ARC, with acid etching prior to adhesive insertion; Group C: Single Bond Universal (SBU-2) + Rely X ARC. The samples were stored in a bacteriological incubator at 37°C with 100% humidity for 48h and were subsequently cross-sectioned to obtain 3 dentine discs 1mm in thickness. Forty-five specimens were subjected to the push-out test. **Results:** Through the analysis of variance and Tukey's test, it was found that SBMP showed, with statistical significance ($p < 0.05$), highest bond strength when compared with the SBU-1 and SBU-2 systems. The observed difference in the discs was located in the cervical portion. **Conclusion:** The three-step adhesive system had higher bond strength with the substrate than the self-etching adhesive only in the disc in the cervical portion; further, statistically, the prior application of phosphoric acid in SBU-1 did not affect its bond strength significantly.

Keywords: Dental Pins; Post and Core Technique; Adhesives; Dentin-Bonding Agents.

Introduction

The excessive loss of the coronal tooth structure caused by caries, previous restorations, and impact on crown fractures are the main reasons for the use of intrarradicular retainers, in order to re-establish the function of the tooth [1]. It is noticeable that when endodontic treatment is performed with excessive instrumentation, it can result in thinner dental walls, significantly reducing the ability of the teeth to withstand functional forces and resulting in the occurrence of fractures [2].

The use of intracanal retainers is required, although for elements with reduced tooth remaining, metal and ceramic retainers can increase the occurrence of fractures. However, fiberglass retainers, when associated with resin cements and adhesive systems distribute the functional forces most likely to resist fracture [2,3]. In addition, for a strong dental adhesion, the substrate surface must be clean and there must be an increase in the surface energy, so that adequate adhesion can occur [4].

The present study was aimed at comparing (1) the bond strength of three-step adhesive systems and self-etch (2) the influence to promote or not acid etching prior to the application of self-etching adhesive, and (3) the bond strength at different depths in root canals using fiberglass retainers.

Material and Methods

Ethical Aspects

This study was approved by the Ethics Committee of the UFF (Fluminense Federal University, Niterói, RJ, Brazil) under the protocol number 01544312.1.0000.5243.

Data Collection

We used roots of 5 upper molars without any curvature, stored in distilled water until the time of the experiment. The roots were removed from the crown with the aid of a diamond disk (KG Sorensen, Cotia, Brazil) under refrigeration and sectioned in a cervical-apical direction in order to standardize the length. Then, we proceeded to attach the roots with the aid of a device. A high-speed turbine, coupled with a dremel device (mod. 220, Joinville, Brazil), with spherical diamond tips FG1012HL (KG Sorensen, Cotia, SP, Brazil) and cylindrical with a conical end diamond tips FG3122 (KG Sorensen, Cotia, SP, Brazil), were used to create cylindrical cavities 7mm in depth and 1.4 mm in diameter in the dentine.

To minimize the variables with respect to the dentin, it was decided to use the roots of the same tooth in the following three experimental groups:

- Group A: Adper Scotchbond Multipurpose Plus, SBMP (3M ESPE, Sumaré, SC, Brazil), fabricated according to the following dental preparation protocol: treated with 37% phosphoric acid for 15s, rinsing with water for 15s, drying with absorbent paper, activator application for 10s, air drying, primer application for 10s, air drying and catalyst application for 10s and air drying;

- Group B: Single Bond Universal, SBU-1 (3M ESPE, Sumaré, SC, Brazil), fabricated according to the following preparation protocol: treated with 37% phosphoric acid for 15s, rinsing with water for 15s, drying with absorbent paper, adhesive application for 20s, air drying for 5s, and photopolymerization for 20s;
- Group C: Single Bond Universal, SBU-2 (3M ESPE, Sumaré, SC, Brazil), fabricated according to the following dental preparation protocol: adhesive application for 20s, air drying for 5s, and photopolymerization for 20s.

The following protocol was chosen for the cementation of the fiberglass retainers:

- Group A: silane application (Prosil, FGM, Joinville, SC, Brazil) on retainer (Reforpost No. 1, Angelus, Londrina, PR, Brazil), air drying, catalyst application on the retainer for 10s, air drying, cement insertion (Rely X ARC, 3M ESPE, Sumaré, SP, Brazil) using a lentulo drill (Mani, Wilcos, Petrópolis, RJ, Brazil), retainer adjustment in the dentin tube, excess removal and photopolymerization for 40s (Optilight Max LD, Ribeirao Preto, SP, Brazil);
- Groups B and C: silane application (Prosil, FGM, Joinville, SC, Brazil) on the retainer (Reforpost No. 1, Angelus, Londrina, PR, Brazil), air drying, cement insertion (Rely X ARC, 3M ESPE, Sumaré, SP, Brazil) using a lentulo drill (Mani, Wilcos, Petrópolis, RJ, Brazil) retainer adjustment in the dentin tube, excess removal and photopolymerization for 40s.

Each group was placed in a bacteriological incubator at 37°C with 100% humidity for 48 h. The dental roots were cut transversely using a diamond disc with water cooling (Excet Labcut1010, Enfield, USA) and an initial portion of 0.5mm was discarded. Three discs with 1mm thickness each were obtained: one third from the cervical area, another third from the cervico-medium area, and the last third from the middle area.

The 45 specimens, properly identified and marked on the crown side, were subjected to a universal testing (AG-X Plus, Shimadzu, Kyoto, Japan) machine for the push-out test carried out with a load of 100N at a speed of 0, 5mm/min by using a cylindrical tip 1 mm in diameter.

To ensure that the shear force occurred in the cement-dentin junction, the diameter of the cylindrical tip of the testing machine did not exceed 85% of the channel diameter and the thickness of the specimens was not less than 60% the diameter of the channel [5].

The obtained data were statistically analyzed using the two-way analysis of variance (ANOVA) and Tukey's test. Differences corresponding to $p < 0.05$ were considered significant.

Results

The ANOVA in relation to fixed factors (adhesives and dentin discs) indicated a statistically significant difference ($p < 0.05$) for the bond strength only in the adhesives that under went the test. No statistically significant difference ($p > 0.05$) was observed in the functions of the dentin disc regions or in the interference of the third on adhesive resistance.

Table 1. Results of analysis of variance of the bond strength in adhesives and dentin discs used. Dependent variable: pressure (MPa).

Source of Variation	Sum of Squares	g.l.	Mean Square	Statistical F	p-value
Adhesive	14159.035	2	7079.517	6.029	0.006
Discs	17 23.239	2	861.620	0.734	0.487
Adhesive × Discs	4058.928	4	1014.732	0.864	0.495
Residual	42275.406	36	1 174.317		
Total	316 679.873	44			

$r^2 = 0.867$ (adjusted $r^2 = 0.833$).

Tukey's test at a significance level of $\alpha = 0.05$ indicated the existence of a statistically significant difference between SBMP and SBU-1 adhesives (mean difference = 41.0 MPa, p-value = 0.006) and also between SBMP and SBU-2 adhesives (mean difference = 32.9 MPa, p-value = 0.033). The difference between SBU-1 and SBU-2 adhesives was not statistically significant (mean difference = 8.1 MPa, p-value = 0.033).

Therefore, the analysis of the adhesives used indicated that the bond strength corresponding to SBMP was statistically significantly different ($p < 0.05$) from that corresponding to the other two adhesive systems, SBU-1 and SBU-2, with average values that exceeded the average values of these two groups. It was also observed that the average bond strength for SBU-1 and SBU-2 adhesives did not show any statistically significant difference ($p > 0.05$).

Table 2. Descriptive statistics of bond strength (MPa) of adhesive systems used.

Adhesive	n	Average	s.d.(*)	Min	Max	Median	i.q.r.(*)
SBMP (**)	15	99.842	35.9587	46.47	180.42	97.81	39.385
SBU-1 (**)	15	58.817	40.6366	3.45	124.83	59.94	56.945
SBU-2 (**)	15	66.935	22.0982	41.60	122.47	62.71	29.230

*s.d.: standard deviation; i.q.r.: interquartile range in Tukey's test; **SBMP: Scotchbond Multipurpose Plus; SBU-1: Single Bond Universal with acid etching; SBU-2: Single Bond Universal without acid etching.

The Figure 1 show the distributions of the bond strength of the adhesives tested; the highest position in the scale for the SBMP adhesives can be observed.

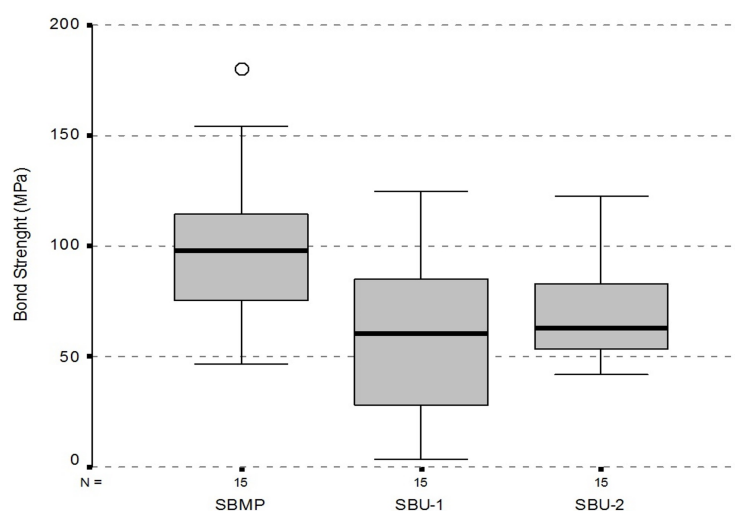


Figure 1. Bond strength values according to the adhesive systems ScotchBond Multi-Purpose Plus (SBMP), Single Bond Universal with acid etching (SBU-1) and Single Bond Universal without acid etching (SBU-2).

Considering the dentin discs, variation in the bond strength was observed only in the disc corresponding to the cervical portion. In this portion, the bond strength corresponding to SBMP showed a statistically significant difference ($p < 0.05$) compared to the other two systems SBU-1 and SBU-2, with average values that exceeded the average values of these two groups. It was also observed that the average bond strength for SBU-1 and SBU-2) did not show any statistically significant difference ($p > 0.05$), as listed in Table 3.

Table 3. Descriptive statistics of bond strength (in MPa) of adhesives used according to dentin disc area.

Discs	Adhesive	n	Average	s.d.(*)	Min	Max	Median	i.q.r.(*)
1	SBMP (**)	5	100.518	29.4156	56.66	133.72	100.84	27.630
	SBU-1 (**)	5	44.484	23.9250	4.82	64.97	51.39	18.640
	SBU-2 (**)	5	57.870	17.1898	41.82	81.67	53.81	25.870
2	SBMP (**)	5	81.158	11.0465	71.03	97.81	77.76	13.550
	SBU-1 (**)	5	68.624	40.9878	3.77	104.41	66.39	38.430
	SBU-2 (**)	5	75.782	29.2337	53.61	122.47	62.71	31.960
3	SBMP (**)	5	117.850	51.9229	46.47	180.42	109.85	56.010
	SBU-1 (**)	5	63.344	55.8982	3.45	124.83	58.10	100.960
	SBU-2 (**)	5	67.152	18.9324	41.60	83.91	72.93	30.400

*s.d.: standard deviation; i.q.r.: interquartile range in Tukey's test. **SBMP: Scotchbond Multipurpose Plus; SBU-1: Single Bond Universal with acid etching; SBU-2: SingleBond Universal without acid etching.

It was observed that in the group with discs 3, there was a significant difference in SBMP when compared to SBU1 and SBU2, where the average values for the first was 117.850. The Figure 2 show adhesive distributions according to the dentin discs.

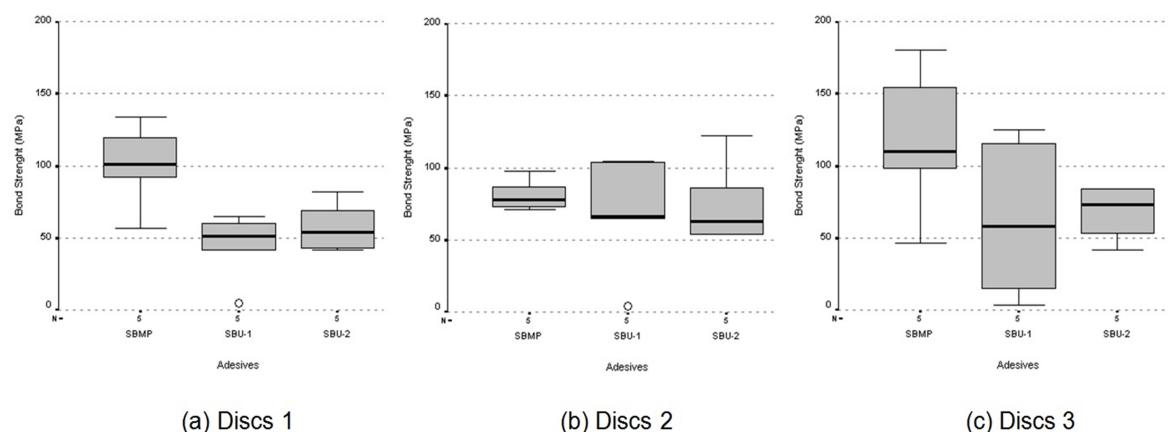


Figure 2. Adhesives distribution of bond strength, according to the dentin discs.

A statistically significant difference was observed between the dental adhesives. The SBMP adhesive had higher bond strength than the other two (SBU-1 and SBU-2) ($p < 0.05$). However, the latter two did not show any difference among themselves ($p > 0.05$). Evaluation of dentin disc groups indicated a statistically significant difference ($p < 0.05$) in the group of discs (1). In the other two disc groups, the three adhesives showed a similar behavior, i.e., showed no statistically significant difference ($p > 0.05$), although SBMP indicated higher MPa values than SBU-1 and SBU-2.

Discussion

On the basis of the results obtained, it can be stated that the three-step adhesive system demonstrated the highest bond strength when compared with the self-etch adhesives. SBMP has a better degree of conversion of monomers, resulting in superior physical and mechanical characteristics that favor micromechanical entanglement with the collagen matrix. This improves the bond strength when compared to self-etch adhesives and corroborates the results described in the literature [5,6].

The self-etch adhesives have a simplified technique for modifying the smear layer: by incorporating with an adhesive layer. Their bond strength was lower than that of SBMP. Therefore, it can be stated that the three-step system has better micromechanical entanglement and chemical bonding with the collagen matrix [7-9].

In an attempt to increase the micromechanical entanglement and bond strength, prior acid etching was performed on SBU-1. However, it showed no statistically significant difference when compared with SBU-2. Moreover, other studies [10-13] confirmed the findings of the present study.

All groups showed a lower bond strength in the case of discs 2 and 3. This result could be attributed to a lower amount of intertubular dentin and a higher amount of sclerotic dentin [14-17]. Moreover, there are limitations pertaining to the adhesive systems, such as difficulty of adhesive permeation and complete encapsulation of exposed collagen fibers [4]. Further, polymerization shrinkage may lead to adhesive failure and intraradicular retainer insertion decreases the amount of cement, increasing the cohesive strength and C-factor. These facts may explain why narrow canals can generate a ratio of 20 to 100, which is considered unfavorable for adhesion [14,18,19].

Conclusion

On the basis of the methodology used and results obtained, we conclude that (1) the three-step adhesive system had higher bond strength to the substrate than the self-etch adhesives, (2) there was no difference when prior acid etching was used in groups with self-etch adhesives, and (3) the cervical dentin had better bond strength in all groups.

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