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Push-out bond strength and sealing ability of etch-and-rinse and self-etching adhesives used for fiberglass dowel bonding at different depths of the root canals

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Resumo

O objetivo deste estudo foi avaliar a resistência de união por push-out e o selamento marginal de sistemas adesivos convencionais e autocondicionantes utilizados para cimentação de pinos de vidro intrarradiculares em diferentes profundidades. Noventa raízes de pré-molares humanos (45 para os testes de push-out e 45 para os de microinfiltração) tiveram os canais preparados com profundidades padronizadas e foram aleatoriamente distribuídas em 3 grupos (n = 15) de acordo com o sistema adesivo utilizado: Adper Scotchbond Multi Purpose (3M ESPE); Adper Single Bond 2 (3M ESPE); Clearfil SE Bond (Kuraray). As raízes receberam pino de fibra de vidro com cimento resinoso. Para os testes de push-out, as raízes foram cortadas radialmente em 3 diferentes profundidades para obter cortes seriados de aproximadamente 1 mm de espessura. Uma máquina de ensaios mecânicos (Emic) foi utilizada para os ensaios de push-out. Para os testes de microinfiltração, as raízes foram seladas e imersas em solução de azul de metileno a 2%, pH 7,0 por 2 horas. As raízes foram cortadas radialmente em 3 diferentes profundidades para obter cortes seriados com espessura de 1 mm e a microinfiltração foi avaliada em lupa estereoscópica por 3 examinadores calibrados que atribuíram escores de 0 a 3. A Análise de Variância e o teste de Tukey para os testes de push-out mostraram que não houve diferenças significativas entre os sistemas adesivos ($p > 0,05$), mas houve entre as profundidades, com maiores valores de resistência de união para o terço cervical e apical. Para os ensaios de microinfiltração, os testes de Kruskal-Wallis e de Friedman mostram que não houve diferença significativa entre os adesivos e entre as profundidades ($p > 0,05$). Os sistemas adesivos convencionais e autocondicionantes apresentaram semelhante resistência de união e de selamento marginal para a cimentação de pinos de fibra de vidro, havendo maior resistência de união nos terços mais cervicais e apicais dos canais.

Palavras-chave: Resistência de união por push-out; microinfiltração; pinos de fibra de vidro; sistema adesivo.

Abstract

The aim of this study was to evaluate the push-out bond strength and sealing ability of etch-and-rinse and self-etching adhesives used for fiberglass dowel bonding at different depths of the root canals. Ninety human pre-molar roots (45 for the push-out tests and 45 for the microleakage tests) had their canals prepared with standardized depths and were randomly allocated into 3 groups (n = 15) according to the adhesive system used: Adper Scotchbond Multi Purpose (3M ESPE); Adper Single Bond 2 (3M ESPE); Clearfil SE Bond (Kuraray). They were restored with fiberglass dowel and resin cement. For the push-out tests, the roots were radially cut at 3 different depths to obtain serial cuts with approximately a thickness of 1 mm. A universal testing machine (Emic) was used for the push-out test. For the microleakage group, roots were sealed, and immersed in a 2% methylene blue solution, pH 7.0, for a 2 hours period. Roots were radially sectioned at 3 different depths to obtain serial cuts with a thickness of approximately 1mm and microleakage was evaluated in stereoscopic loupe by three calibrated evaluators who attributed scores from 0 to 3. The Analysis of Variance and the Tukey test for the push-out tests showed no significant differences among adhesive systems ($p > 0.05$), but differences among the depths with higher bond strength at the cervical and apical depth. For microleakage, Kruskal-Wallis and Friedman tests showed that there was no significant difference among the adhesive systems tested or different depths of cut ($p > 0.05$). The total-etching and self-etching adhesive systems had similar bond strength and ability of marginal sealing for the cementation of fiberglass dowels and that higher bond strength was obtained at the most cervical and apical depths of the root canals.

Keywords: Push-out bond strength; microleakage; fiberglass dowels; adhesive system.

INTRODUCTION

Endodontically treated teeth can receive different restorative procedures to provide retention of the coronal portion, such as pre-manufactured dowels or cast metal cores[1,2]. Among different types of dowels, the nonmetal type present some advantageous characteristics such as great preservation of root dentin, elastic modulus similar to that of dentin, retention of the definitive restorative materials and reinforcement of the remaining cervical region of the tooth with a structurally compromised root. Thus, stresses applied on the tooth are diffused to root structure and the occurrence of irreversible fractures is minimized[2]. It is considered that the indication for dowels in endodontically treated teeth is strictly related to the retention of restorative material and to the distribution of tensions generated on the teeth[1,2].

The retention of a fiberglass dowel in the root canal is a critical point for clinical success, since it must help the dowel to support different thermal and mechanical conditions present in oral environment[3,4]. The indication of adhesive cementation techniques has enabled a significant increase in the retention of pre-manufactured dowels[5,6] and the use of adhesive systems associated with resin cements has been shown to provide an effective bond of dowels to root dentin, being a relevant factor when choosing the adhesive cementation technique[7-9]. However, there is difficulty in obtaining adequate polymerization in deep regions of the root canal, because the photoactivation source is positioned in the cervical region, which makes it difficult for the light to penetrate into deep regions, whereas it is able to light polymerize the resin material efficiently in the cervical third of the root canal[10-12]. Thus, the cervical third is responsible for the major retention of dowels cemented with resin cements, as in this area, light polymerization is easily obtained and there is a higher number of dentinal tubules than in the apical third of the root, favoring adhesion[8].

Simplified adhesives that combine the primer and adhesive into one application (such as the two-step etch-and-rinse and one-step self-etching adhesive systems) are often used for the adhesive cementation of dowels. However, incompatibility of resin cements with these adhesives has been observed[13-15], possibly due to the inactivation of tertiary amines in the resin cement by the acidic monomers present in them and also due to high permeability[16]. Although Kivanç, Görgül[17] (2008) observed greater fracture resistance in teeth in which dowels were cemented with self-etching adhesive systems, there are no reports that evaluate the marginal sealing capacity of different adhesive systems used for fiberglass dowel cementation.

Therefore, the aim of this study was to evaluate the push-out bond strength and sealing ability of two etch-and-rinse and a self-etch adhesive system associated with resin cement used for fiberglass dowel bonding at different depths of the root canal.

MATERIALS AND METHODS

After approval of the Local Ethics Committee (process 060259/2008), maxillary and mandibular uniradicular pre-molars were selected and stored in aqueous thymol solution (0.1%). Teeth were submitted to debriding with periodontal curettes and had their roots separated from crown with a water-cooled diamond saw. Roots measuring 10 ± 1 mm were obtained and this measure was checked with a digital caliper (Mitutoyo Corporation, Tokyo, Japan). Subsequently, the mesio-distal and buccal-lingual diameters were verified with a digital caliper. Within these measures, a mean value was obtained for each root, resulting in a standard measure that was used to select the 90 roots (45 for the push-out bond tests and 45 for the microleakage tests). This standardization was necessary so that the remaining root walls would not interfere in results.

The methodology used for standardized preparation of roots was similar to that proposed by Mitsui et al.[18] (2004). The preparation was performed with a low-speed handpiece, under water/air spray. Initially, wear was performed with a round diamond bur (#1016HL kg Sorensen, Barueri, São Paulo, Brazil) until a depth of 7 mm into the root canal was achieved. A second wear procedure was performed with a round diamond bur (#3017HL kg Sorensen, Barueri, São Paulo, Brazil), achieving a depth of 5.0 mm. Finally, the cervical third was prepared with a round diamond bur (#3018HL kg Sorensen, Barueri, São Paulo, Brazil) to a depth of 3 mm. The 7.0, 5.0 and 3.0 mm depths were controlled by fitting diamond burs with a rubber stop. This procedure promoted a tapered shape root canal preparation.

To facilitate handling of roots during all procedures and to allow the photopolymerization light to reach only the coronal region of the root, roots were positioned on a 21 mm diameter and 34 mm high acrylic mold, filled with putty condensation silicone. The 90 prepared roots were randomly distributed into 3 groups ($n = 15$) according to the adhesive systems used for dowel bonding: Three-step etch-and-rinse adhesive system (Adper Scotchbond Multi Purpose, 3M ESPE, St Paul, MN, USA); Two-step etch-and-rinse adhesive system (Adper Single Bond 2, 3M ESPE, St Paul, MN, USA); Two-step self-etching adhesive system (Clearfil SE Bond, Kuraray Medical Inc, Japan).

Table 1. Adhesive systems, manufacturer, batch number, composition and instructions for use

Adhesive systems manufacturer (Batch number)	Composition	Instructions for use
Adper scotchbond multipurpose 3M ESPE, St Paul, MN, USA (7MT; 7PX; 8RG)	Primer: Water, HEMA, copolymer of acrylic and itaconic acids. Bond: Bis-GMA, HEMA.	Treat surfaces with a 35% phosphoric acid gel for 15 seconds, rinse for the same time and gently dry. Apply one layer of primer and gently dry for 5 seconds. Apply bond and light-cure for 10 seconds.
Adper single bond 2 3M ESPE, St Paul, MN, USA (7MT; 8RL)	Bis-GMA, HEMA, copolymer of acrylic and itaconic acids, water, ethyl alcohol, glycerol 1, 3-dimethacrylate, diurethane dimethacrylate, silane treated silica, water.	Treat surfaces with a 35% phosphoric acid gel for 15 seconds, rinse for the same time and gently dry. Then apply the adhesive system in two consecutive layers; evaporate the remaining solvent with a brief, gentle dry air jet for 10 seconds and light polymerize for 20 seconds.
Clearfil SE bond Kuraray Medical Inc, Japan (00727A; 01042A; 00841A; 01230A)	Primer: 10-MDP, HEMA, hydrophilic dimethacrylate, di-Camphorquinone, N, N Diethanol-p-toluidine, water. Bond: 10-MDP, Bis-GMA, HEMA, hydrophobic dimethacrylate, di-Camphorquinone, N,N Diethanol-p-toluidine, Silinated colloidal silica.	Apply primer and leave it in place for 20 seconds, evaporate the volatile ingredients with a mild oil-free air stream. Apply bond, make the bond film uniform with a mild oil-free air stream and light-cure it for 10 seconds.

**Based on information provided by manufacturers: MDP: Methacryloyloxydecyl dihydrogen phosphate, HEMA: 2- hydroxyethyl methacrylate; Bis-GMA: Bisphenol A diglycidyl ether dimethacrylate.*

Table 1 describes the commercial brand name, manufacturer, batch number, composition and instructions for use.

Pre-manufactured glass fiber dowels (Reforpost, Angelus, Paraná, Brazil) 1.5 mm in diameter were cut with a diamond bur in a high-speed turbine with water-cooling to obtain a length of 8 mm. For the glass fiber dowel cementation, a silane agent (Silano, Angelus, Paraná, Brazil) was applied over the entire dowel surface for 1 minute with a disposable brush, followed by the application of the bond (Scotchbond Multi Purpose Adhesive/3M ESPE, USA) that was light-polymerized for 20 seconds at each surface. This bond was used on the dowel surface for all groups.

After the application of each adhesive system, the resin cement (Rely X ARC/3M ESPE, USA) was manipulated and taken inside the root canal with a Lentulo spiral. The glass fiber dowel was positioned in the central point of the root. All dowels were checked to ensure that they had a layer of resin cement all around them and that they were not adhered to the dental structure. The excess resin cement portion was removed and the cement was light polymerized for 40 seconds at the the cervical region, using a visible light-curing unit (Optilight Plus, Gnatus Equipamentos Médico Odontológicos LTDA, São Paulo, Brazil) with a mean output range of 527 mW.cm^{-2}, which was periodically measured with a radiometer (Newdent Equipamentos LTDA, São Paulo, Brazil). After this, the roots were removed from the supporting cylinders and stored in a humid environment in a bacteriological oven at 37 °C for 24 hours.

1. *Push-out Bond Strength Tests*

The 45 roots were cut in a radial direction, at different depths, using a metallographic cutter with double-faced diamond disc. Initially a 0.5 mm thick cervical cut was made, which was discarded to enable slices that were parallel to one another to be obtained. After this, the following cuts were obtained: a) cervical cut; b) middle cut, and c) an apical cut, which had an approximate thickness of 1.0 mm, obtained from the cervical region in the direction of the apical region. The 1 mm thickness of each slice obtained was checked with a precision caliper, in the range from 0.9 to 1.1 mm thickness.

Next, the values of the internal diameter of the canal at both extremities of the slices obtained were checked with a precision caliper to obtain the correct bond strength value. Each slice was placed in the electromechanical testing machine (Emic DL 2000, São José dos Pinhais, Paraná, Brazil) with the lower internal diameter of the canal facing up. Each slice was placed on a holed device do perform the push out tests. The device that applied the force in the dowel region was a metal rod that was placed on the cemented dowel in the center of the slice (Figure 1). The universal test machine (Load cell of 20 kgf) applied a force in the apico-coronal direction, at a speed of 0.5 mm/min, displacing the cemented dowel.

The values were recorded in N (Newton) and a formula was applied to calculate the bond area that corresponded to the following values:

Bonded area = $\{[k.(R + r)].[h^2 + (R - r)^2]^{0.5}\}$, in which k = is the constant of 3.1416; R = largest radius of the cemented fiber dowel; r = smallest radius of the cemented fiber dowel; h = slice thickness. The bond strength calculation (in MPa) was obtained by dividing de "force" (in N) by the area (in mm^2).

After the mechanical tests, all the specimens were evaluated with regard to fracture mode, under a stereoscopic loupe at 20× to 40× magnification, classifying it as follows: 1) adhesive fracture between the glass fiber dowel and cement; 2) adhesive fracture between the cement and dentin; 3) cohesive cement fracture; 4) cohesive dentin fracture; 5) cohesive dowel fracture.

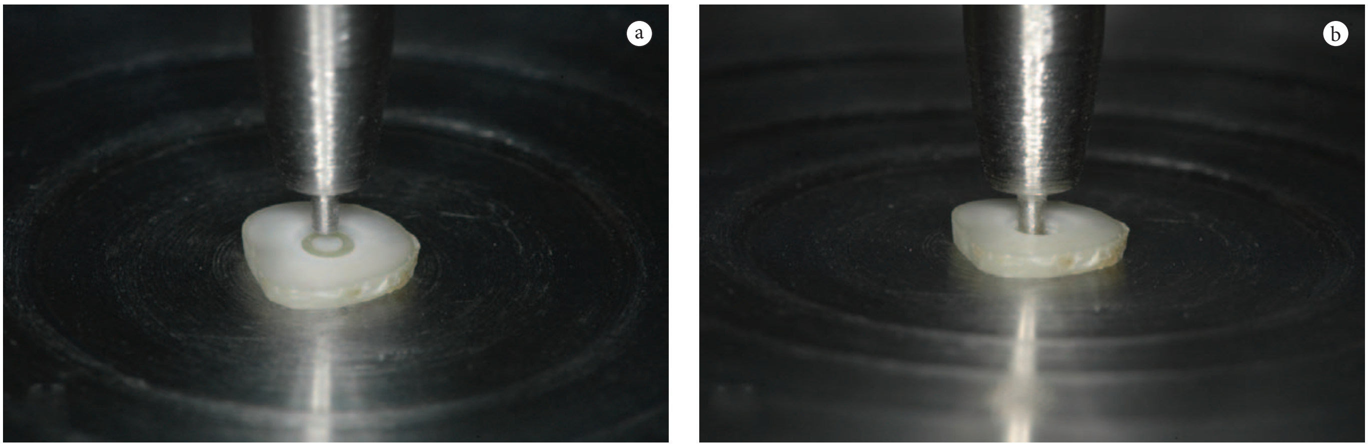

Figure 1. a) Slice placed on a holed device to perform the push out tests. See the metal rod device placed on the cemented dowel in the center of the slice; b) Slice after the push out test.

2. *Microleakage Tests*

The procedures for adhesive systems application and glass fiber dowel cementation were the same as those described previously. However, when necessary, excessive dowel and cement in the cervical portion were removed with a water-cooled diamond bur, in a single movement. Irregularities in the coronal portions of root were removed with coarse-grit aluminum oxide discs (Sof Lex, 3M ESPE, USA).

A 4 mm diameter mold of adhesive paper was positioned on the cervical portion of the root to avoid excessive dye penetration in this region. The remaining root was covered with 3 layers of a nail varnish, with exception for the region at the entrance of the root canal, where the dowel had been cemented.

After 24 hours, roots were immersed in a 2% blue methylene solution, pH 7.0, for a 2 hour period. They were washed in distilled and deionized water and kept at relative humidity, at 37 °C. Roots were dried and sectioned in the same manner as described for the push-out bond strength tests, obtaining 3 slices: a) cervical cut; b) middle cut, and c) an apical cut, which had an approximate thickness of 1.0 mm obtained from the cervical region in the direction of the apical region. The 1 mm thickness of each slice obtained was checked with a precision caliper (ranging from 0.9 to 1.1 mm thickness).

Dye microleakage was evaluated quantitatively under a stereoscopic magnifying glass, at 30× magnification, by three calibrated evaluators, in a blind study, being classified by scores. The dye microleakage evaluation was realized at the 3 depths, in which buccal and lingual walls were observed, attributing scores according to the presence or absence of dye penetration. Scores were classified as follow: a) score 0: absence of dye penetration; b) score 1: presence of microleakage that achieves an extension of the circumference at the interface between adhesive and cement, which is smaller than half of this total circumference; c) score 2: presence of microleakage that achieves an extension of the circumference at the interface between adhesive and cement, which is higher than half of this total circumference, but not observed all around it; d) score 3: presence of microleakage all around the circumference at the interface between adhesive and cement.

3. *Statistical Analysis*

For the push-out results, the Analysis of Variance (ANOVA) in the split plot design and the Tukey test at a level of significance of 5% were applied to observe differences among depths and adhesive systems. For the fracture mode, the data were analyzed by means of frequency distribution tables (absolute and relative). The statistical program used was SAS (Institute Inc., North Caroline, United States of America, Release 9.1, 2003).

The microleakage results were analyzed by the Kruskal-Wallis non-parametric test. For each adhesive system and considering the different depths, the Friedman non-parametric test was used. The statistical calculations were made at a 5% level of significance. The statistical program used was Bioestat 4.0 (Mamirauá, Pará, Brazil).

RESULTS

According to Table 2, there was no statistically significant difference among the adhesive systems evaluated as regards bond strength ($p > 0.05$). As regards depth, statistically significant difference was observed between the cervical and middle thirds ($p < 0.05$), values being higher in the cervical third. However, no statistically significant differences were observed between the cervical and apical, and between the middle and apical depths ($p > 0.05$).

Table 3 shows the distribution and frequency of type of fracture according to depths of cut for each type of adhesive system. One specimen from Clearfil SE Bond group was removed from the analysis due to lost during preparation (n = 14). It was observed that there was higher frequency of cohesive failures in dentin in the cervical third and adhesive failures between the cement and dentin in the middle and apical thirds fracture modes for all adhesive systems.

Table 4 represents the distribution of microleakage score frequencies of the tested groups. It was verified that there were no

Table 2. Bond strength (mean and standard deviation in MPa) as a function of adhesive systems and depths of cut

Adhesive systems	Cervical	Middle	Apical	Tukey
Adper scotchbond multipurpose	9.30 (3.26)	6.63 (4.32)	6.64 (4.39)	A
Adper single bond 2	9.83 (3.67)	8.95 (4.30)	10.09 (4.22)	A
Clearfil SE bond	10.87 (4.35)	8.66 (3.52)	9.87 (6.07)	A
Tukey	A	B	AB	

**Means followed by different letters (capitals letters in the lines and lower case letters in the columns) differ among them by the Tukey test, p < 0.05.*

Table 3. Distribution and frequency (%) of type of fracture according to depths of cut for each type of adhesive system

Adhesive system	Fracture mode	Cervical		Middle		Apical	
		n	%*	n	%	n	%
Adper scotchbond multipurpose	1	1	*100.0*	0	*0.0*	0	*0.0*
	2	5	*16.7*	11	*36.7*	14	*46.7*
	3	3	*100.0*	0	*0.0*	0	*0.0*
	4	6	*54.5*	4	*36.5*	1	*9.0*
	5	0	*0.0*	0	*0.0*	0	*0.0*
Adper single bond 2	1	3	*50.0*	2	*33.3*	1	*16.7*
	2	4	*20.0*	7	*35.0*	9	*45.0*
	3	0	*0.0*	3	*60.0*	2	*40.0*
	4	8	*57.1*	3	*21.4*	3	*21.4*
	5	0	*0.0*	0	*0.0*	0	*0.0*
Clearfil SE bond	1	0	*0.0*	4	*66.7*	2	*33.3*
	2	5	*22.7*	9	*40.9*	8	*36.4*
	3	1	*100.0*	0	*0.0*	0	*0.0*
	4	8	*61.5*	1	*7.7*	4	*30.8*
	5	0	*0.0*	0	*0.0*	0	*0.0*

*The percentage values correspond to the rate of fracture mode according to the root canal depth (line comparison).

significant differences between adhesive systems used, or among sections ($p > 0.05$). Therefore, the three adhesive systems had a similar performance in preventing marginal microleakage.

DISCUSSION

Due to pre-existing caries lesions and cavity preparation to promote access to root canals, endodontically treated teeth present loss of dental structure, which reduces their capacity to absorb and resist intra-oral forces, and consequently, their mechanical resistance. In these situations, intraradicular dowels are indicated to promote retention for the restoration and reinforcement of root structure in situations with weakened or thin-walled endodontically treated teeth when using glass fiber dowels associated with resin cements or lined with composite resin[1,6,10,19,20].

Glass fiber dowels are used directly in a single session, and require the removal of less dental tissue for cementation, due to their shapes being slightly tapered or parallel to the intraradicular preparation shaping, and being available in different diameters to suit the different sizes of teeth. When compared with metal dowels, those made of glass fiber significantly reduce root fractures in vitro, in addition to resulting in a more conservative fracture mode, presenting less failure in relation to fracture strength[10,17]. Nevertheless, the bond to intraradicular dentin is still critical, and clinically it has been verified that the majority of failures found are related to dowel displacement[7], as well as differences in the mechanical properties of the materials for intraradicular dowel retention (cement – dowel – dentin), as the combination of these different materials may generate the concentration of stresses when load is applied to the system[21].

The occurrence of microleakage at the tooth/cementation interface is also an important factor in the maintenance of intraradicular dowels[22]. The ideal restorative material or cement would be the one that could bond intimately to dental tissues, have physical properties similar to dental structure, be easy to manipulate and have favorable esthetics[23,24].

Table 4. Frequency of marginal microleakage scores in experimental groups

		Scores for marginal microleakage							
		0		1		2		3	
Adhesive systems	**Section**	**n**	%	**n**	%	**n**	%	**n**	%
Adper scothbond multipurpose	Cervical	5	*33.3*	0	*0.0*	4	*26.7*	6	*40.0*
	Medium	5	*33.3*	1	*6.7*	6	*40.0*	3	*20.0*
	Apical	6	*40.0*	1	*6.7*	8	*53.3*	0	*0.0*
Adper single bond	Cervical	3	*20.0*	3	*20.0*	7	*46.7*	2	*13.3*
	Medium	5	*33.3*	2	*13.3*	6	*40.0*	2	*13.3*
	Apical	5	*33.3*	3	*20.0*	6	*40.0*	1	*6.7*
Clearfil SE bond	Cervical	4	*26.7*	4	*26.7*	7	*46.7*	0	*0.0*
	Medium	5	*33.3*	6	*40.0*	4	*26.7*	0	*0.0*
	Apical	7	*46.7*	5	*33.3*	2	*13.3*	1	*6.7*

In addition to factors related to the histological characteristics of the intraradicular root canal dentin[7], the composition of the irrigant solutions and types of filling material[19,25,26] and dentinal drying[27], one of the main purposes of adhesive dentistry is to obtain marginal sealing, by the application of an adhesive system.

The use of resin cements is able to form an effective bond to dentin[23,24] when an adhesive system is used. Although the type of cement and light source for photo curing are capable of influencing bond strength during intraradicular dowel cementation[12], the effective bond to root dentin promoted by associating adhesive systems with resin cements is relevant factor in adhesive cementation, thus the most indicated would be the use of dual action resin cements[5,8,10,12,28].

Dual cements may minimize the problems related to the difficulty of light reaching the most apical portions of the root canal, with polymerization being activated by the chemical fraction of the activators, and thus, the most cervical portions would be benefited by light sensitization[10,11,29]. In some respects, this effect was observed in the present study when the bond strength was evaluated by the push-out test, and it was found that the highest bond strength values were presented in the most cervical region, in spite of no differences having been found in comparison with the values in the apical third. The low bond strength in the middle third may be explained by the low effectiveness of light and a greater cement thickness compared to the apical third (in which region the dowel is more seated in the canal preparation), which may not have been completely polymerized, when compared with the apical third. The apical third has a thinner layer of cement, and was probably able to be completely polymerized by the chemical fraction of the cement. Another factor that should be considered as being responsible for the difference in the degree of polymerization is the heterogeneity in which root dentin is presented. It was verified that there was alteration with regard to the density and diameter of the dentinal tubules in the regions, and after etching, there could have been an increase in the surface area[30]. These factors contributed to the occurrence of greater adhesion to the dentin in the cervical and middle thirds[7], and consequently, the cervical portion was shown to present higher bond strength than the apical portion[12,31].

Nevertheless, it could be observed that microleakage between adhesives and resin cement were not statistically significant at different depths, corroborating with the findings of Foxton et al.[9] (2003) that showed no differences in microhardness of the resin cement and bond strength to dentin in both cervical and apical regions. Since the microleakage in endodontically-treated teeth restored with intraradicular dowels occurs commonly in the cervical portion, it is important to perform adequate polymerization of the resin cement to avoid penetration of bacteria or fluids, which begins in this region and goes toward the apical region.

In addition to the resin cement, the selection and application of the adhesive system is fundamental for retention of intraradicular dowels in the root canal, because they are passive. The use of simplified adhesive systems that combine primer and bond into one application (two-step etch-and-rinse and one-step self-etching) promote adverse compatibility, which may compromisse the bond between dentin and dual-cure resin cements. This occurs due to the incomplete polymerization of the chemical component of these cements, because of hydrophilic acid monomers present in these simplified adhesives (as in Adper Single Bond 2)[14,15,16], which react with the alkaline-pH tertiary amines. These tertiary amines are responsible for starting the chemical reaction and their inactivation inhibit their action as activators of the polymerization reaction of the cement[13]. After photopolymerization of these adhesives, the superficial layer that is not polymerized (due to oxygen inhibition) contains acid monomers that come into direct contact with the chemical resin, inactivating the tertiary amines. Due to the fact that dual-cure resin cement was used, portions of cement located in the apical regions (where it is more difficult for the light to reach) may be polymerized only by the chemical reaction[23]. This may compromise the tooth-resin agent interface even further, due to the contact of simplified adhesive systems that can inhibit the chemical polymerization of cements.

In the present study, no differences were observed between the adhesive systems, regardless of the test used, refuting the problem related to the incompatibility of simplified adhesive systems with dual resin cements. In the intraradicular dentinal substrate, special care should be taken with the adhesive application technique, due to the geometric configuration of the cavity, which may difficult adequate contact of the primer and/or adhesive with the cavity walls. Also, it is difficult to remove water during the washing process with the use of conventional systems, since excessive removal or the presence of water could respectively result in collapse of the collagen fibers or in dilution of the primer[32,33]. With the introduction of self-etching adhesive, this problem has been eliminated, since the acid monomer demineralizes the dentin in a less aggressive manner, in addition to avoiding the need for washing, but provides bond strength values similar to those of conventional adhesives[34]. However, the use of an etch-and-rinse adhesive in combination with a dual-cure cement to lute fiber posts was shown as the most stable luting procedure if compared with a self-etch resin-based cement or a self-adhesive cement, as assayed by thermocycling of bonded specimens by Mazzoni et al.[35] (2009).

Bearing in mind the results of this study, it was verified that the evaluated adhesive systems provided similar bond strength values and microleakage scores for the cementation of intraradicular dowels. It should be considered that there is adequate formation of a hybrid layer during the steps of pre-fabricated dowel cementation under exposure to light for good root canal sealing in the most cervical portions[8]. Nevertheless, in the deeper regions, it is also imperative to activate the resin cements by dual polymerization to obtain these results[9,12]. Since the problems related to bond failures in teeth treated endodontically with the use of intraradicular dowels generally occur in the cervical portion (where contact between the cementation line and the oral medium occurs), it is important to perform adequate polymerization of the resin cement, in order to prevent the penetration of bacteria or fluids through this region and in the apical direction. Although the three adhesive systems behaved in a similar manner for the cementation of glass fiber intraradicular dowels, it may be suggested that the use of the two-step self-etching system is favored due to the greater ease of technical application and lower number of clinical application steps. However, it should be considered that the selection of an adhesive system is related to the professional's own affinity for the suitable technique for applying it.

CONCLUSION

It was concluded that the total-etching and self-etching adhesive systems had similar bond strength and marginal sealing ability for the cementation of intraradicular glass fiber dowels, and that higher bond strength was generally obtained at the cervical and apical depths of the root canals.

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