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Full Length Research Paper

Effect of chlorhexidine on the shear bond strength of self-etch adhesives to dentin

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The aim of this study was to investigate the effect of chlorhexidine on shear bond strength of self-etch adhesives to dentin. The crowns of 60 sound human premolars were horizontally sectioned to expose the coronal dentin. Dentin surfaces were polished with 320 grit silicon carbide papers, and were randomly divided into 4 groups (n = 15). In group 1, two-step self-etch adhesive resin (Clearfil SE Bond) was used. In group 2, the surface was rinsed with chlorhexidine 2% solution prior to Clearfil SE bond application. In groups 3 and 4, the procedure was repeated similar to groups 1 and 2. In this case, one-step self-etch adhesive resin (Clearfil S3 Bond) was used. Then Z100 composite resin was applied. Subsequent to thermocycling, the shear bond strengths were measured. Data were analyzed using one-way ANOVA. In this study, $p < 0.05$ was considered significant. There were no significant differences between groups ($p = 0.321$). The use of 2% chlorhexidine had no effect on the shear bond strength of two-step and one-step self-etching adhesive resins. Moreover, there was no significant difference in the shear bond strength values between two-step and one-step self-etching adhesive resins.

Key words: Chlorhexidine, shear bond strength, one-step self-etch adhesive resin, two-step self-etch adhesive resin.

INTRODUCTION

One of the problems in restorative dentistry is the complete elimination of caries-affected dentin. If bacteria remain in the prepared cavity, recurrent caries may ensue. Even when a proper seal is achieved, these bacteria may be able to proliferate. The toxins produced by such bacteria penetrate into the pulp chamber and result in pulpal inflammation. A probable solution to this problem is the irrigation of the prepared cavity with a disinfecting agent. Some researchers have proposed the use of chlorhexidine (de Castro et al., 2003).

During the past two decades, chemical and technical advances have resulted in increases in the bond strength of dentin-bonding adhesive resins. However, early loss of the dentin-resin bond and its low durability are problems that still affect the adhesive bonds. Failure of the bond is predominantly the result of degradation of the hybrid layer at dentin-resin interface and also the degradation of dentin collagen fibers. Although the hydrophilic nature of dentin has led to the use of hydrophilic and ionic resin compounds in the formulation of total-etch adhesives, this formulation has contributed to lack of durability and stability of resin matrix and its failure through water absorption. In addition, temperature fluctuations, masticatory loads and chemical degradation due to acids and enzymes threaten the durability of the tooth structure-composite resin bond with time (Soares et al., 2008).

On the other hand, dentin matrix contains endopeptidases called matrix metalloproteinases (MMPs) which have a key role in tooth formation and dentin caries. It seems the release and activation of MMPs during dentin bonding procedures is responsible for the degradation of collagen fibers which have not been completely covered in the hybrid layer. Total-etch and self-etch bonding resins can activate dentin MMPs (Tay et al., 2006; Nishitani et al., 2006). Chlorhexidine can inhibit the activation of dentin MMPs even at low concentrations. Therefore, it can function as an inhibitor for MMPs in addition to its role as a disinfectant (Carrilho

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Table 1. Mean shear bond strength (MPa) and standard deviations for Clearfil SE Bond and Clearfil S3 Bond.

Type of pretreatment	Clearfil SE Bond			Clearfil S3 Bond		
	Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Without chlorhexidine pretreatment	22.86 ± 0.61	21.56	23.91	22.13 ± 1.12	19.99	24.08
With chlorhexidine pretreatment	22.07 ± 1.34	20.14	24.55	21.74 ± 2.78	18.78	31.34

et al., 2007a, 2007b; Hebling et al., 2005).

Various studies have investigated the influence of chlorhexidine on the bond strength of various dentin-bonding resins. It has been reported that 2% chlorhexidine does not influence the microtensile bond strength of Single Bond, Prime & Bond NT and Clearfil SE Bond adhesive resins (de Castro et al., 2003). The same results have been reported with One Step and Optibond Solo adhesive resins (Say et al., 2004). All the adhesive resins evaluated in the above-mentioned studies are fifth-generation (total-etch) and sixth-generation (two-step self-etch) bonding systems. However, little information is available in relation to the effect of chlorhexidine with the use of seventh-generation (one-step self-etch) adhesives.

The aim of the present study was to investigate the effect of chlorhexidine on the shear bond strength of one-step and two-step self-etching dentin bonding agents. Two null hypotheses were tested: (1) The use of 2% chlorhexidine has no effect on the shear bond strength of two-step and one-step self-etching adhesive resins; and (2) There is no difference in the shear bond strength values between two-step and one-step self-etching adhesive resins.

MATERIALS AND METHODS

In the *in vitro* study, 60 sound human premolars which had been extracted for orthodontic reasons were selected. The teeth were immersed in 0.5% chloramines T solution immediately after extraction and stored at 4°C. One week before the initiation of the study, the teeth were cleaned of any calculi and tissue tags and stored in distilled water. The teeth were randomly divided into 4 groups (n = 15). Then they were horizontally cut using diamond disks (Diamant Gmbh, D & Z, Goerzallee 307, 14167 Berlin, Germany) in a high-speed handpiece under air and water spray; the long axes of the teeth were perpendicular to the surfaces cut. After removal of the enamel, dentin was exposed. Then they were mounted in self-curing acrylic resin. The cut surfaces of the samples were level with the acrylic resin surface. The exposed dentin surfaces were polished with 320-grit silicon carbide abrasive papers under running water so that a very smooth surface and a homogenous smear layer were achieved.

In group 1, two-step self-etching adhesive resin, Clearfil SE Bond (Kuraray Medical Inc., Tokyo, Japan) was used according to the manufacturer's instructions. In group 2, the procedures were the same as those in group 1 except for the fact that the dentin surface was rinsed with 2% chlorhexidine digluconate (Cavity Cleanser, BISCO Inc., Schaumburg, IL, USA) for 30 s with a microbrush; then chlorhexidine remnants were removed with a new microbrush and the surface was dried in a manner in which the dentin surface preserved its shiny appearance (Brackett et al., 2007). In group 3, one-step self-etching adhesive, Clearfil S3 Bond (Kuraray Medical Inc., Tokyo, Japan) was used according to manufacturer's instructions. In group 4, the procedures were the same as those in group 2 except for the fact that instead of two-step self-etching adhesive resin, one-step self-etching adhesive, Clearfil S3 Bond (Kuraray Medical Inc., Tokyo, Japan) was used according to the manufacturer's instructions.

In all the groups, Z100 composite resin (3M ESPE, St. Paul, MN, USA) and transparent plastic cylinders with an inner diameter of 2 mm and a height of 3 mm were used to produce composite cylinders. The transparent cylinders were filled with A-1 shade composite resin and placed on the prepared surface of dentin which had been fixed with a clamp. Then the cylinders were covered with a piece of clear celluloid matrix band and pushed with finger pressure. Extra composite resin was removed with an explorer. Astralis 7 light-curing unit (Ivoclar Vivadent AG, FL-9494 Schaan/Liechtenstein) was used to cure composite resin for 40 s; the curing light was directed for 20 s from each direction with the tip of the device perpendicular to the surface, barely touching the surface. The samples were placed in distilled water and stored at 37°C for 24 h. Then, the samples underwent a thermocycling procedure at 5/55°C consisting of 500 cycles (de Castro et al., 2003), with a dwell time of 30 s and a transfer time of 10 s. Subsequently, universal testing machine (Hounsfield Test Equipment, Model H5K-S, Tinius Olsen Ltd, Surrey, England) was used to measure shear bond strength values of the samples. A chisel-shaped blade was placed at composite-tooth interface and applied a shearing force at a strain rate of 1 mm/min. Subsequent to shear bond strength test, the samples were evaluated under a stereomicroscope (Nikon, Tokyo, Japan) at ×20 by two examiners and the failure mode was determined as follows (de Castro et al., 2003):

1. Adhesive failure: dentin was intact and there were no traces of composite resin on dentin surface.
2. Cohesive failure: failure had occurred in the bulk of the dentin or the restorative material.
3. Mixed failure: the failure was a combination of adhesive and cohesive failures.

Data for shear bond strength were analyzed with one-way ANOVA. Statistical significance was set at $p < 0.05$ in this study.

RESULTS

Shear bond strength

The means and standard deviations of the shear bond strength of Clearfil SE Bond and Clearfil S3 Bond are represented in Table 1. Analysis of data with one-way ANOVA did not demonstrate any significant differences between the groups ($p = 0.321$). In other words, the use of 2% chlorhexidine had exerted no influence on the shear bond strength of the two-step self-etching (Clearfil

Table 2. Mode of failure for self-etch adhesives.

Type of pretreatment	Clearfil SE Bond			Clearfil S3 Bond		
	Adhesive	Cohesive	Mixed	Adhesive	Cohesive	Mixed
Without chlorhexidine pretreatment	6	8	1	5	7	3
With chlorhexidine pretreatment	6	6	3	7	5	3

SE Bond) and one-step self-etching (Clearfil S3 Bond) adhesive resins.

Failure mode

Table 2 shows the results of the evaluation of failure modes of the specimens under a stereomicroscope. Failures were predominantly of the adhesive and cohesive types in all the groups.

DISCUSSION

Recurrent caries is the most important reason for replacing restorations. Recurrent caries might result from polymerization shrinkage which leads to the penetration of bacteria into the tooth-restoration interface. Another factor involved in recurrent caries is the bacteria present in the smear layer. In other words, bacteria can survive in the smear layer for a long time after cavity preparation. The toxins released from these bacteria can penetrate into the pulp and irritate it, resulting in pulpal inflammation. Irrigation of the prepared cavity with a disinfectant to eliminate these bacteria might be effective (Bocangel et al., 2000).

Chlorhexidine is a broad-spectrum disinfecting agent, which has been recommended for the irrigation of prepared cavities because of its disinfecting properties. Chlorhexidine has a positive electrical charge, whereas bacterial cell membrane has molecules with negative charges. Interaction between the positive and negative charges produces an affinity in chlorhexidine molecules for bacteria. The interaction between chlorhexidine molecules and bacteria increases the permeability of bacterial cell membranes, resulting in the penetration of destructive agents into the cytoplasm and the ultimate death of the microorganism (Soares et al., 2008).

The results of this study did not demonstrate any significant differences between the groups. In other words, the use of 2% chlorhexidine had no effect on the shear bond strength of the two-step self-etching (Clearfil SE Bond) and one-step self-etching (Clearfil S3 Bond) adhesive resins to dentin.

The results of the present study are consistent with the results of previous studies on total-etch and two-step self-etch adhesives (de Castro et al., 2003; Bocangel et al., 2000; Soares et al., 2008; Perdigao et al., 1994; Erhardt et al., 2008). They showed that chlorhexidine had no negative effects on the bond strength of adhesive systems, which might be attributed to the compatibility of chlorhexidine with the adhesive resins used. It has been reported that the effect of disinfecting agents, such as chlorhexidine, on bonding of composite restorations depends on the type of adhesive resins and their interaction with disinfecting agents (Tulunoglu et al., 1998).

However, the results of this study are not consistent with the results of other studies conducted on total-etch adhesives (Cao et al., 1995; Gürgan et al., 1999; Meiers and Shook, 1996). In the earlier mentioned studies, chlorhexidine affected the bond strength adversely. The discrepancies in the results might be attributed to differences in dentin surface preparation techniques and material properties such as modulus of elasticity (Van Noort et al., 1991). Moreover, the differences in adhesive resins used can be considered as another reason for different results.

However, the results of this study do not coincide with the results of previous studies in which the use of chlorhexidine increased the composite-dentin bond strength in total-etch adhesive resins (Carrilho et al., 2007a; Pappas et al., 2005; Brackett et al., 2009). The differences in the results might be attributed to the fact that in the earlier mentioned investigations, chlorhexidine was used subsequent to acid etching and/or it was used in combination with other disinfecting agents. In total-etch adhesive resins, the use of chlorhexidine after acid etching prevents collagen fiber degradation and preserves the hybrid layer due to its inhibitory effect on matrix metalloproteinases (which are responsible for the degradation of collagen fibers); therefore, the bond strength increases.

In this study, there were no statistically significant differences in the bond strength of one-step and two-step self-etch adhesives, which might be attributed to the similar monomer composition [10-methacryloyloxydecyl dihydrogen phosphate (MDP)], used in the Clearfil SE Bond and Clearfil S3 Bond since the monomer composition of adhesives can influence their bonding ability to tooth structure (Davidson and Feilzer, 1997; de Oliveira et al., 2007).

Given the results of this study, further investigations are warranted using scanning electron microscopy to evaluate the effect of chlorhexidine on the interface of different adhesives and dentin. Furthermore, the effect of other disinfecting agents on dentin-composite bond strength in one-step self-etch adhesives needs to be evaluated in future studies.

Based on the results of this study, two null hypotheses were accepted. Within the limitations of this study, it was concluded that the use of 2% chlorhexidine had no effect on the shear bond strength of two-step and one-step self-etching adhesive resins. In addition, there was no difference in the shear bond strength values between both adhesive resins.

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