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Original article

In Vitro Effect of Different Cavity Disinfectants on Shear Bond Strength of Resin Composites to Dentin with Two Adhesive Approaches

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Abstract

Aim. *To evaluate the effect of three different cavity disinfectants on the shear bond strength of resin composites to dentin applied with two different adhesive approaches.* ***Methods***. *Eighty extracted human third molar teeth were randomly separated into 4 basic groups. GP1 is the control group (no treatment), group 2, 3 and 4 dentin surfaces were treated with the following cavity disinfectants, respectively; 0.12 % chlorhexidine solution (CHX), 5 % sodium hypochlorite (NaOCL) and 0.15 % benzalkonium chloride (BAC). Then each group was divided into two subgroups (n=10) according to the adhesive approaches. Ten specimens were bonded with the total-etch approach and the other ten specimens were bonded with the self-etching approach. The resin composite was then applied incrementally to the dentin surfaces using a cylindrical-shaped Teflon tube (3mm diameter × 3mm height). After 24h water storage in an incubator, the specimens were then mounted and tested to determine shear bond strength.* ***Results***. *Dentin surfaces treated with different cavity disinfectants showed significantly higher shear bond strength than the control group. The Tantum disinfectant group had the highest shear bond strength value among the cavity disinfectant groups. For the three types of cavity disinfectant, the total-etch approach showed higher shear bond strength than the self-etch approach.* ***Conclusion***. *Treated the dentin surface with cavity disinfectant before adhesive bonding improved the shear bond strength between resin composite and dentin surface in particular with the total-etch adhesive approach.*

Keywords. *Cavity Disinfectant, Shear Bond Strength, Chlorhexidine, Sodium Hypochlorite, Benzalkonium Chloride, Adhesive.*

Introduction

Cavity preparation is an operative procedure that attempts to remove all infected caries dentin prior to placing a restoration. However, residual bacteria might be entrapped within dentinal tubules or the smear layer during and after the cavity preparation, which considers one of the major problems in restorative dentistry [1,2]. Therefore, effective removal of infected dentin and prevention of micro-organisms growth under a restoration prevents the development of secondary caries, reduce microleakage, pulpal inflammation, and hence reduce the need for replacing the restoration [2]. Adhesive systems are responsible for the bonding of restorative material to the tooth structure. Thus, the longevity of adhesive restoration is directly associated with the effectiveness of adhesive systems [3].

Dentin is considered an intrinsically moist and heterogeneous tissue which makes adhesion to this tissue more technique sensitive compared to enamel [1]. Despite the evolution of adhesive systems, the hybrid layer suffers degradation over time, causing loss of adhesive resistance, which influences the longevity of restorations [4]. The degradation of the adhesive interface is related to several factors, such as oral fluids and bacteria present in situ,4 leading to degradation of polymers and other organic components. For those reasons, cavity disinfection becomes an important step before the restorative procedures.5 This step is described as cleaning the dental systems, making it as innocuous as possible [4].

Long-term studies have shown that the bond strength of resin bonded to dentin decreased over time due to collagen degradation within the hybrid layer [2,6,7]. Therefore, elimination of the residual bacteria from the cavity surfaces after cavity preparation is of major importance using a disinfectant solution [2]. The use of cavity disinfectants which are MMPs

inhibitors is a strategy to prevent degradation of dentin bonds and to increase the longevity of bonded restorations [7].

Many chemicals have been tested as cavity disinfectants, including chlorhexidine digluconate (CHX), disodium ethylene diamine tetra-acetic acid dehydrate (EDTA), sodium hypochlorite (NaOCL), Ozon (O3), Er:YAG laser and iodine. Generally, a potential problem in the use of a disinfectant before dentin bonding agents is the possibility of an adverse effect on the bond strength of the composite resins to dentin [8,9]. Therefore, the present in vitro study aimed to evaluate the effect of three different cavity disinfectants on shear bond strength of resin composites to dentin applied with two different adhesive approaches; total-etch and self-etch.

Methods

A total of 80 extracted non-carious human third molar teeth were stored in 0.9 % isotonic saline in the refrigerator, until use within one month. The teeth were then embedded in a mould filled with cold-cure acrylic resin up to a level of 0.5 mm from the cement-enamel junction. The roots were embedded inside a cylindrical-shaped mould filled with self-cured acrylic resin (Acrostone, Egypt), till the cervical line with the exposed occlusal surface plane was parallel to the floor.

The specimens were randomly divided into 4 groups:

Group 1 (n=20): dentin surface without treatment (normal saline). This group served as a control group (Otsuka, India).

Group 2 (n=20): Dentin surface treated with 0.12 % chlorhexidine gluconate (Cariax, Barcelona, Spain).

Group 3 (n=20): Dentin surface treated with 5 % sodium hypochlorite (Sword, Istanbul).

Group 4 (n=20): Dentin surface treated with benzalkonium chloride (Tantum Verde, Egypt).

Each group (Group 1-4) was further divided into 2 subgroups (n=10 per subgroup) according to the adhesive approach as follows; Total-etch adhesive (TE) and Self-etch (SE). Specimens of each group (Gp1-Gp4) were soaked in the intended disinfectant solution for one minute. Specimens were then rinsed with water for 10 seconds and gently dried with air for 10 seconds.

In each group, ten specimens (n=10) were bonded using the total-etch approach and the other Ten specimens (n=10) were bonded using the self-etch approach. In the total-etch approach, the pretreated dentinal surface was treated with 37% phosphoric acid for 15 seconds, rinsed with water for 15-20 seconds, and gently dries with absorbent paper. In the self-etch approach group, the pretreated dentinal surface was treated with the application of the G-Premio Bond without prior application of 37 % phosphoric acid. This dentin bonding agent G-Premio Bond can be used as a total-etch or as a self-etch dentin bonding agent according to instructions given by the manufacturer's.

The bonding agent was applied to dentin surfaces with a brush for 5 seconds and then cured by light for 10 seconds (Light Emitting Diode-Elipar, 3M ESPE, Germany). The Nanohybrid resin composite (Nexcomp Nano-hybrid, META BIOMED, Korea) was incrementally (2mm) placed in the cylindrical-shaped Teflon tube (3 mm in diameter and 3 mm in height) to the dentin surface. Each specimen was incrementally cured for 20 seconds with the same light curing unit. The specimens were stored in an incubator at 37oC in 100 % humidity for 24 hours. Shear bond strengths of the specimens were measured with a Universal Testing Machine (Model 3345; Instron Industrial Products, Norwood, USA) at a standard crosshead speed of 0.5 mm/min and using a knife-edge blade placed parallel to the bonded surfaces, to induce fracture.

Fractured specimens were placed under USB digital microscope (U500x Digital Microscope, Guangdong, China), to view the complete failure area at x35. The modes of failure were categorized as follows:

A: Adhesive failure (failure located in the adhesive interface).

C: Cohesive failure (failure located in the composite or dentin substrate).

M: Mixed failure (failure of interfacial and partially cohesive in dentin/composite interface).

Data were statistically analyzed by one-way ANOVA and the t-test. The level of significance was chosen at P=0.05. All statistical analyses were carried out with the SPSS 25 software system.

Results

For the average value of shear bond strength (SBS) of resin composite to dentin surface treated with different cavity disinfectants groups as follows; normal saline (control group) (7.58 ± 0.85), Sword (10.70 ± 3.83), Cariax (10.73 ± 3.64), and Tantam (13.39 ± 7.59). The

SBS is higher for disinfectant groups than that for the control group (normal saline). The SBS for the Tantam group was higher than that of the Sword and Cariax groups (P=0.002). For the average value of SBS of resin composite to dentin according to the adhesive bonding approach (self-etch VS total-etch). The average values for SBS were 9.4 ± 3.76 for self-etch and 11.79 ± 5.79 for total-etch. The t-test revealed a statistically significant difference (P=0.031) for SBS among the total-etch group as compared to the self-etch group. For the comparison between SBS of self-etch and total-etch adhesive approaches according to different types of cavity disinfectants (Figure 1).

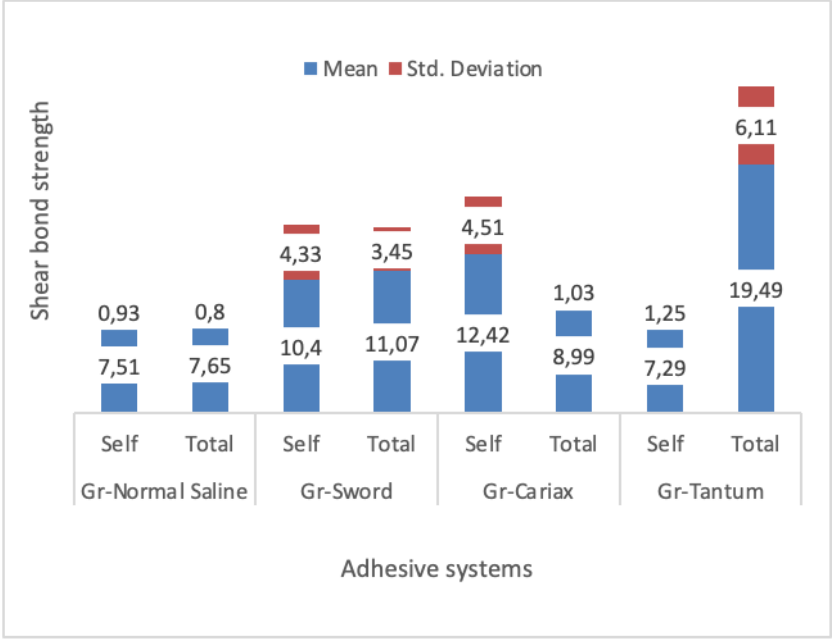

Figure 1. Comparison of average shear-bond-strength (SBS) by type of adhesive

For the control group, the difference was negligible with nearly equal values for mean and standard deviation (P=0.717). SBS for the self-etch was 7.51 ± 0.93 and for the total-etch was 7.65 ± 0.80). For the three types of disinfectants, the total-etch adhesive approach showed higher SBS with the Tantam group (P=0.000), and Sword group (P=0.710). On the other hand, the self-etch demonstrated statistically significant higher SBS with the Cariax group (P=0.031). The highest value of SBS was observed in the Tantum with total-etch (19.49 ± 6.11), followed by Cariax with a elf-etch adhesive approach (12.42 ± 4.51), then Sword total-etch (11.07 ± 3.45). The lowest value of SBS was reported with the self-etch and the Tantam (7.29 ± 1.25).
The mixed failure is higher than the adhesive failure in both the total-etch and the self-etch adhesive approaches. Examples of the adhesive and mixed failure patterns are shown in Figure 2.

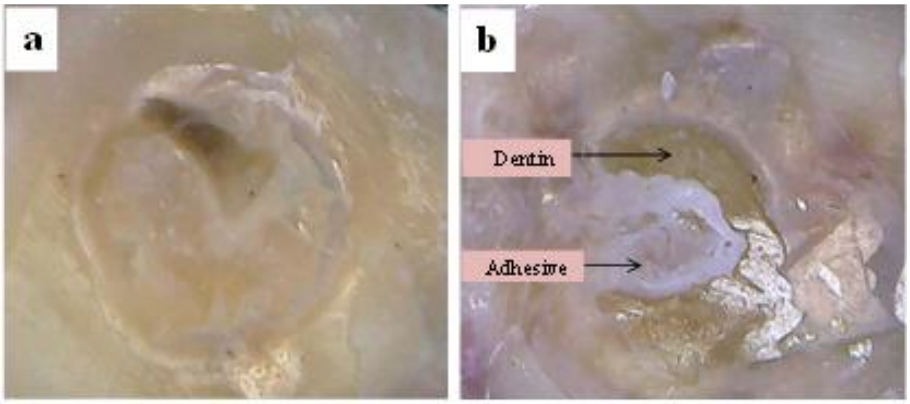

Figure 2. Failure patterns: a) adhesive failure pattern. b) mixed failure pattern.

The highest failure was of the mixed type and observed in 7 specimens of the Cariax group treated with a total-etch adhesive approach. The lowest mixed failure was seen in the self-etched Tantam group (1 specimen). The most common adhesive failure was reported among

the self-etch Tantam group (6 specimens). The least common adhesive failure was observed in the self-etch saline group (1 specimen) (Figure 3).

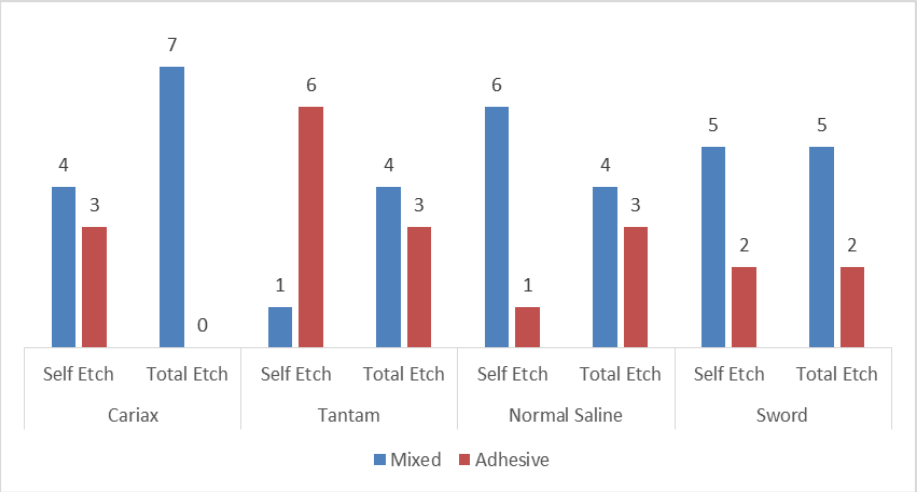

Figure 3. The distribution of frequencies of failure (Mixed vs Adhesive) according to study group.

Discussion

Conventional removal of carious tissue and cavity preparation procedure does not guarantee the complete elimination of oral cariogenic bacteria that might be entrapped within dentin tubules, which may induce secondary caries or pulpal inflammation. Therefore, the success in the elimination of bacteria during cavity preparation and before the insertion of the restoration may increase the longevity of that restoration [10]. Disinfectant solutions are commonly used to eliminate bacteria from the cavity preparations, but a potent problem is that it may affect the bonding ability of resin composite resin to tooth structure [2,8]. The efficacy of these disinfectant solutions has been reported in a number of studies [10-12].

Results of the present study revealed that treated dentin surface with disinfectant solutions such as normal saline as the control group, chlorhexidine gluconate (CHX), sodium hypochlorite (NaOCL) and benzalkonium chloride (BAC), positively affected the shear bond strength of resin composite to dentin.

Benzalkonium chloride (BAC) has been commonly used as a cavity disinfectant in clinical practice because of its disinfecting action and wettability property [13]. Results of the present study are in line with those of Sharma et al., [9] who suggested that when benzalkonium chloride-based, and chlorhexidine solutions are used as a cavity disinfectant, an etch-and-rinse bonding system should be preferred [9].

Likewise, Chlorhexidine (CHX) has been applied as a good cavity disinfectant for many years [4]. Because it has a rewetting capacity and a strong affinity to the tooth structure [14]. It seems that CHX would improve the bond strengths of the adhesive to dentin, which is in agreement with our study [14]. However, El-Housseiny and Jamioum [15] in 2001, reported that the application of chlorhexidine before acid etching did not significantly affect the bond strength of total-etch dentin bonding agent to dentin, which are in contrary to our study [10,15-17]. The explanation for this could be that chlorhexidine was not washed off the dentin debris remained on the dentin surface, and in the tubules, which may account for the decrease in bond strength [17]. These results could be due to the difference in the protocol of applications of cavity disinfectant, concentration of the solution, type of dentin bonding agents and composite restoration used.

Sodium hypochlorite (NaOCL) may be beneficial for adhesive system performance. It increased the bonding .18 In the current study, the results showed an improvement in bond strength of total-etch adhesive with 5 % NaOCL cavity disinfectant, which was not in line with the study, done by Aries et al., in 2005 who found that the 10% NaOCL did not affect bond strength when the total-etch technique was used [19]. The explanation of this could be related to the high concentration of NaOCL used, which affected the collagen removal property of NaOCL that promotes the bond strength [19]. The present results revealed that the highest value of SBS was observed in 0.12 % CHX followed by 5% NaOCL with self-etching approach, which is not in line with study done by Reddy et al., who suggested that pretreatment with 2% CHX and 2% NaOCL, had a negative effect on the shear bond strength of self-etching bonding systems [20]. The explanation of this could be related to the concentration of cavity disinfectants used, protocol of disinfection of dentin surface, and type of composite material used [20].

Several studies have reported higher bond strengths of resin composite to dentin when etch-and-rinse adhesive systems, were used rather than with self-etch systems, after CHX and NaOCL pretreatment, which supported the results of our study [8,13,21]. However, the findings of the present study were not in line with the result done by Mohammed Hasan et al., in 2014, who suggested that the dentin surfaces treated with cavity disinfectants recorded higher shear bond strength for self-etch bonding agent than the etch-and-rinse bonding agent [22]. The explanation of this could be related to the self-etching adhesives having higher pH values than the phosphoric acid used are not rinsed away [22].

In the present study, the self-etch adhesive recorded statistically significantly higher SBS with the 0.12 % CHX cavity disinfectant group, which is not in line with a study done by Suma et al., who reported that 2 % CHX cavity disinfectant recorded significantly lower SBS when compared with control group [23]. The explanation of this could be related to the residual moisture of the 2 % CHX, contaminates the bonded surface and alters the ability of the hydrophilic resin in the self-etch system to seal the dentin, disinfectant concentration and protocol of dentine surface treatment [23-25].

The present study was in line with previous results obtained by Mohammed Hassan et al., in 2014, who found higher SBS values of the nanohybrid composite than micro-hybrid composite bonded to dentin specimen using self-etch adhesive [22].

The present results revealed that mixed failure is higher than adhesive failure in both types of adhesive approach which were in agreement with the results of Hassan et al., who reported an increased percentage of mixed failure among groups of disinfectants [22]. On the other hand, the results are disagreed with study done by Reddy et al., in 2013, who observed that the fractured pattern was mostly adhesive failures. This result could be related to testing methodology, materials properties, and size of specimens [20].

Conclusion

Treatment of the dentine surface with the three cavity disinfectants, before adhesive bonding, improves the SBS between resin composite and dentin, especially with the total-etch approach compared with the self-etch adhesive approach.

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