ORIGINAL ARTICLE

EVALUATION OF THE BEST METHOD TO DECONTAMINATE THE TOOTH-RESIN INTERFACE

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ABSTRACT

Background: Contamination is the most common problem of the dental composites when the incremental technique is used to restore a tooth, which results in low bond strengths between the tooth and the resin composite. This study was designed to evaluate the best method to decontaminate the tooth resin interface by analysing the shear bond strength of two bonding agents used to bond a hybrid composite, Herculite XRV to a hydroxyapatite disk with and without contamination and decontamination procedures.

Methods: The hydroxyapatite discs were acid-etched, rinsed and air-dried prior to bonding. Specimens were divided into 4 groups, Control group: Normal bonding, Group 1: Contamination, normal bonding Group 2: Contamination, air-blow, normal bonding Group 3: Contamination, rinse, normal bonding. Following bond application, the composite (4mm diameter, 4 mm height) was build-up in 2 X 2 mm increments cured with an LED curing light. Specimens were stored in damp gauze sealed in a bag at 37 °C for 24 hours prior to testing. The shear bond strength was determined and mode of failure assessed using an Optical Microscope.

Results: The three-step etch and rinse adhesive, OptiBond FL, exhibited higher bond strength (43.2 ± 2 MPa) than OptiBond Solo Plus (32.3 ± 2.4 MPa) without contamination. However, OptiBond Solo plus was more resistant to bond failure and responded better to decontamination methods.

Conclusion: Air drying was found the most reliable method for decontamination. However, isolation remains the key factor in protecting the resin-tooth interface by any contamination.

Keywords: Composite Resin; Decontamination; Isolation; Saliva; Dental restoration failure.

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INTRODUCTION

Dental Composites are very sensitive to moisture and contamination. Preventing composites from salivary contamination and moisture is a very common problem faced in modern dentistry and they are considered as the most common causes for bond failure. Due to its increased usage, the importance of contamination of composites is becoming very important[1-3]. Clinically, contamination by saliva is the most common problem when the incremental technique is used to restore a tooth. Numerous articles suggest that contamination of the tooth structure (enamel and dentine) results in low bond strengths between the tooth and the resin composite[4-8]. Areas such as gingival margins are very difficult to isolate due to excess salivation[9]. Wet conditions effect etched enamel, the pores become plugged and there is a decrease in resin penetration, which results in impaired resin tags formation that are less in number and shorter in length[10]. Exposure to even a minimum amount of saliva for a very short period affects the bond strength because there is a deposition of an organic coating, which adheres on the surface and is resistant to washing[11-13].

Many methods have been tried to reverse the effects of salivary contamination. Drying the surface, with or without rinsing, partially improved the bond strengths in between resin increments. However, surface drying and applying one-bottle adhesive almost fully recovered the bond strength values because of the solvents within the system that remove saliva and moisture from the surface[14]. Etching the tooth surface followed by rinsing and priming significantly improves the bond strength values. In modern dentistry, new self-etch adhesives have been developed, which contain the acid and the primer in a single bottle for uninterrupted use on the tooth structure. This results in the elimination of stepwise application of the etchant, rinsing and then drying the tooth surface[15]. Conditioning of the tooth surface has the upper hand of a simplified application technique and results in effective etching and bonding of the enamel and dentine in a single step without compromising bond strength[16]. Hydrophilic primers and self-etching primers have been affected by moisture contamination; and many studies have evaluated their effects[14]. In dry conditions, both the self-etching and hydrophilic primers exhibited adhesive failure[14,15]. In moist conditions, the failure occurred at the enamel-adhesive interface for the hydrophilic primer[14], also demonstrated that blood contamination greatly reduced the bond strength. Rinsing and drying the surface resulted in restoration of the bond strength up to 70% when compared to the control group (uncontaminated). However, applying a one bottle adhesive resulted in restoration of the bond strength to almost control levels[15].

Another major contaminant encountered in everyday clinical practice is compressor oil that comes from air compressors, which are not well maintained. Contamination with oil has proven to give unreliable and unpredictable bond strength values and needs to be evaluated further[17]. The purpose of this study was to evaluate the effects of salivary and compressor oil contamination on the shear bond strength of the hydroxyapatite-resin interface and to find out the best method to recover the bond strength to control values.

MATERIALS AND METHODS

Two commercially available bonding agents were used. A three step etch and rinse adhesive, OptiBond FL and a two-step etch and rinse adhesive, OptiBond Solo plus were used. The Resin Composite used was Herculite XRV™ (Kerr, UK), which is a microhybrid dental composite developed using the Vita® shade system. Exhibiting excellent handling properties, Herculite XRV enables anatomical shaping without composite slumping. An LED curing light (3M™ ESPE) was used to cure the resin composite. It emits a wavelength of 470 nm. In order to analyse the in-vitro strength of the bonded interface, hydroxyapatite discs were used in this experiment as the substrate. The selection of hydroxyapatite discs for the experiment was to standardize the experiment and to obtain more reproducible results. These hydroxyapatite discs or hydroxyapatite ceramic tablets have 20% microporosity (Plasma Biotal Limited, UK). The contaminants used in this experiment were artificial saliva and compressor oil. The saliva used in this experiment was artificial saliva manufactured by A.S Pharma. This contains an exclusive combination of mucin (a constituent of mucus) obtained from the stomach of pigs and xylitol (a sugar), used as an artificial saliva for the treatment of dry mouth (reference). The oil used in this experiment as the contaminant was a high grade compressor oil (SB-46, Bambi, UK).The composite resin specimens were divided into 4 groups, which are described in Table 1.

Table 1: Composite resin specimens according to the groups and contaminations applied.

S. No.	Groups	Contaminations
1.	Control Group	No contamination, normal bonding procedure
2.	Group 1	Contaminant applied, followed by normal bonding procedure Contaminant applied and immediately blown off by air, followed
3.	Group 2	by normal bonding procedure
4.	Group 3	Contaminant applied and rinsed, followed by normal bonding procedure

The hydroxyapatite blocks were placed on a flat surface and the etchant (Kerr, UK) was applied to cover the whole surface of the hydroxyapatite disk. The ethant was applied for 15 seconds, then it was rinsed thouroughly with water for 15 seconds. Then the hydroxyapatite disks were gently air-dried. Following etching, the PTFE mould was placed on the hydroxyapatite disk and a 2mm composite increment was placed using a composite plastic instrument (UnoDent, UK) This was followed by the placement of a further 2mm composite increment to make 4mm in total. The composite on the top surface of the PTFE mould was evened out using the same plastic instrument. The second increment was light cured for 20seconds and then the composite specimen built up on the hydroxyapatite disk was pushed out from the PTFE mould. The samples were then mounted in a cold-cure acrylic mould to enable them to be mounted in the shear bond test jig.

The preparation of the samples for group 1,2 and 3 was similar to the control group, however, after etching, before the bond was applied, they were contaminated, followed by either direct bonding, airdrying or rinsing. Like the control group, the hydroxyapatite disk was etched using the etchant (Kerr, UK), rinsed and air dried. Following etching, the contaminant (artificial saliva or oil) was applied for 10 seconds using 'bonding brushes' that were supplied with the bonding agents. For each specimen and contaminant, a different bonding brush was used to avoid any mixed contmination or any loss of uniformity. This was then followed by the preparation of the composite specimen as described previously for the control group. For 'Group 1', the contaminant was applied and not removed, for 'Group 2', the application of the contaminant was followed by air drying of the hydroxyapatite disk using a standard air compressor for 5 seconds, and for 'Group 3', the removal of the contaminant by rinsing the hydroxyapatite disk for 5 seconds with water. In each group, standard bonding procedure was carried out prior to the application of the composite.

For the control group, 10 repeat specimens were prepared. For groups 1, 2 and 3, 20 repeat specimens were prepared (10 for each contaminant) for each bonding agent. This makes a total of 70 specimens for each bonding agent. A total of 140 hydroxyapatite blocks will be required for testing the composite with 2 bonding agents and 2 contaminants. After 24 hours, shear bond strength testing was conducted on a sheer testing machine, Instron model No.5567 (Northwood, MA, USA), using a 1kN load cell with a crosshead speed of 1mm/min. The specimens were loaded until they failed and the force was calculated in Newtons (N). After the test, the debonded surfaces were observed under a stero-microscope (Zeiss, Stemi 2000, Carl Zeiss MicroImaging Inc, Germany).

The samples were then assessed for failures and are divided into 3 groups. Cohesive, which is a failure in the hydroxyapatite disk; Adhesive failure is at the bonding interface; and Mixed is a combination of cohesive and adhesive failure. Some samples failed during the preparation and could not be tested for their shear bond strength.

Descriptive statistics, including the mean, standard deviation, standard error, and minimum and maximum values were calculated for each of the groups tested. A one-way analysis of variance (ANOVA) and the Tukey multiple comparison tests were used to compare shear bond strengths of the groups. Significance for all statistical tests was predetermined at $p < .05$. All statistics were performed with SPSS version 17.

RESULTS

Table 2: Mean bond strength of OptiBond FL with and without contaminations in all groups with types of failures.

	OptiBond FL				
	Mean bond strength (±SD)	Cohesive Failure	Adhesive Failure	Mixed Failure	Immediate Failure
	Control Group				
No Contamination	43.2 ± 2	8	-	2	-
Group 1					
Contaminated with saliva	13 ± 1.2	-	4	-	6
Contaminated with oil	38.5 ± 2.4	-	2	6	2
Group 2					
Contaminated with saliva	32.8 ± 2.2	1	2	7	-
Contaminated with oil	33.1 ± 2.4	-	2	6	2
Group 3					
Contaminated with saliva	12.9 ± 0.8	-	3	1	6
Contaminated with oil	24 ± 1.8	-	3	2	5

Table 2 shows the mean bond strength of OptiBond FL in control group, group 1, 2 and 3 with oil and saliva contaminations with the type of bond failures. The mean bond strength of Group 1 contaminated with oil was closest to the controlled group. Group 1 and 3 contaminated with saliva showed the lowest bond strength. However, bond strength of group 2 did not show much difference when contaminated with saliva and oil.

Table 3: Mean bond strength of OptiBond Solo Plus with and without contaminations in all groups with types of failures.

	OptiBond Solo plus				
	Mean bond strength (±SD)	**Cohesive Failure**	**Adhesive Failure**	**Mixed Failure**	**Immediate Failure**
	Control Group				
No Contamination	32.3 ± 2.4	6	-	3	1
	Group 1				
Contaminated with saliva	15.1 ± 1.4	-	3	1	6
Contaminated with oil	29.1 ± 1.8	-	4	4	2
	Group 2				
Contaminated with saliva	31.5 ± 1.7	2	-	6	2
Contaminated with oil	30.3 ± 2.2	-	2	6	2
	Group 3				
Contaminated with saliva	23.5 ± 1.1	-	2	5	3
Contaminated with oil	20.2 ± 2	1	2	5	2

Table 3 shows the mean bond strength of OptiBond Solo Plus in control group, group 1, 2 and 3 with oil and saliva contaminations with the type of bond failures. The mean bond strength of group 2 contaminated with saliva and oil, and group 1 contaminated with oil was very close to control group values, which is also shown in OptiBond FL. Group 1 contaminated with saliva showed the lowest bond strength values.

ANOVA indicated a significant difference between groups ($p < .05$). The highest shear bond strengths were measured in the Controlled Group. The shear bond strengths in Groups I and III were significantly lower than in Group II ($p < .05$). Significant difference was also found between Group II and Controlled Group ($p < .05$).

DISCUSSION

In the control group with no contamination, OptiBond FL, the 3-step adhesive system, when applied on the hydroxyapatite disks showed around 25% higher bond strengths than the 2-step adhesive system, OptiBond Solo Plus. This may be attributed to the fact that the primer and the adhesive are in separate bottles and the filler loading is around 48% for OptiBond FL (3-step) as compared to OptiBond Solo plus (2- step) which has a filler loading of only 15%. According to the manufacturer's instruction leaflet, the increased filler amount results in greater bond strength. This is in accordance with the results obtained in this experiment where OptiBond FL demonstrated higher bond strength values for the control group when compared with OptiBond Solo plus. The bond strength values of OptiBond FL and OptiBond Solo plus for the control group. In a study by Frankenberger, it was shown that the 2-step etch and rinse adhesive exhibited good bond strength and marginal adaptation but Inoue et al demonstrated that bond strengths of OptiBond FL bonded to natural teeth were higher than other adhesives available on the market[18, 19].

In group 1 with the contamination applied followed by normal bonding procedure, it was demonstrated that salivary contamination had a major effect on the shear bond strength of specimens bonded to both, OptiBond FL and OptiBond Solo plus. OptiBond FL showed a decrease in bond strength around 70%, while the bond strength of OptiBond Solo plus decreased around 53%. This is in accordance with a study by Guerriero who demonstrated that saliva had a major effect on bond strength[20]. As mentioned previously, the shear bond strength of OptiBondFL was higher than OptiBond Solo plus in the control group, however, after salivary contamination, there was a decline in the bond strength for both adhesive systems, but OptiBond FL had slightly lower shear bond strength values than OptiBond Solo Plus. When the specimens were contaminated with oil, the bond strengths for both adhesive systems were slightly lower than their control values (around 11% for OptiBond FL and 24% for OptiBond Solo plus) and higher than salivary contaminated specimens. There were more immediate failures for both bonding agents contaminated with saliva as compared to contamination with oil[20].

In Group 2 and 3 where contamination (saliva) was followed by decontamination procedures, water rinsing did not improve the bond strength at all. In fact, the bond strength was more or less the same as the group for OptiBond FL contaminated with saliva. However, there were 6 immediate failures after rinsing with water as compared to no immediate failures when the bond was applied directly after contamination. This suggests that rinsing after salivary contamination was unreliable and the effect of water was worse than the contaminant itself. Airdrying improved the bond strength by 41% as compared to simple rinsing. There were no immediate failures as compared to direct rinsing and all the samples exhibited very similar bond strength values as shown in table 1 and 2. Therefore, airdrying after salivary contamination is a more reliable method of decontamination for OptiBond FL. For OptiBond Solo plus contaminated with saliva and followed by rinsing, the bond strength was remarkably high (23.5 ± 1.1) as compared to direct application of the bond after contamination Air drying improved the bond strength values to almost control levels. This improved the bond strength values and the modes of failure were very similar to the group in which saliva was rinsed. Therefore, OptiBond Solo plus improved the bond strength after water rinsing as compared to OptiBondFL, which had an opposite effect. However, this also resulted in immediate failures and the high bond strength values do not necessarily mean it is a very reliable method. In a study conducted by Erikson et al, air drying the saliva quickly or rinsing with water did not restore bond strengths to normal levels for some of the materials tested[21]. In comparison, the study conducted here showed that airdrying improved the bond strength values for the OptiBond Solo plus to almost control levels, while OptiBond FL had some improvement in the bond strength values. This may be because there was in a difference in substrate and the decontamination procedures were carried out in between increments of composite, unlike the adhesive bond interface in this study.

Water rinsing resulted in extremely low bond strength values for OptiBond FL; however, OptiBond Solo Plus showed an improvement in bond strengths after rinsing. This finding provides new opportunities to test OptiBond Solo plus with more contaminants, preferably in a clinical trial.

For the samples contaminated with oil, in OptiBond FL water rinsing decreased the bond strength by 37% as compared to direct bonding after contamination. It also resulted in more immediate bond failures. Therefore, water rinsing after oil contamination is not recommended for OptiBond FL. When air-dried, it had no immediate failures as compared to 5 immediate failures with rinsing, therefore, air drying proved to be better than rinsing, but not as good as direct bonding without any decontamination procedures.

OptiBond Solo plus had more or less the same bond strength values with or without rinsing. However, after rinsing, there were no immediate failures as compared to a few immediate failures without rinsing. Airdrying also produced very similar results to water rinsing. In other studies, Oil contamination reduced bond strengths, being less detrimental to enamel than to dentine. In this study, oil did not reduce the bond strength significantly with both bonding agents, possibly due to the use of hydroxyapatite blocks, which as the substrate are more similar to enamel than to dentine[22,23].

CONCLUSION

It can be concluded that decontamination procedures vary for different bonding agents. Airdrying was found most reliable method for decontamination. However, isolation remains the key factor in protecting the resin-tooth interface by any contamination.

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CONFLICT OF INTEREST

The authors do not have any financial interest or any conflict of interest.

AUTHORS CONTRIBUTION

This work was carried out in collaboration among all authors. Muhammad Qasim and Omer Yousuf designed the study, wrote the first draft of the manuscript. Omair Anjum wrote the protocol and performed the laboratory procedures and statistical analysis. Behzad Salahuddin managed the analyses of the study. Shoaib Khan and Madiha Pirvani managed the literature searches and References. Shoaib Khan revised the first draft. All authors read and approved the final manuscript.

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