

An Evaluation of Shear Bond Strength of Composite Resin to Enamel under Various Saliva Contaminated Conditions: An *in vitro* Study

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ABSTRACT

To produce good adhesion between composite resin and etched enamel surface, it is necessary to form a microscopically intimate contact between them. Contaminants, like saliva, may interfere with such bonding. Salivary contamination may reduce the bond strength between composite resin and the enamel by 40 to 60%. Recent studies have suggested that only rewashing and drying of the etched and saliva contaminated enamel surface is sufficient in restoring bond strength to the normal ideal condition.

Purpose: To evaluate the effect of saliva contamination on the shear bond strength of composite resin to enamel by using different parameters.

Materials and methods: The highest mean shear bond strength of composite resin was obtained on the uncontaminated enamel surface, and the lowest mean shear bond strength was obtained on the saliva contaminated moist enamel surface.

Results: The mean shear bond strength of composite resin to saliva contaminated, washed and air-dried enamel surface was less than the mean shear bond strength to the dry enamel surface.

Conclusion: This suggests that only rewashing of the saliva contaminated enamel surface is not enough in achieving bond strength equal to that of the uncontaminated enamel surface.

Keywords: Composite resin, Etching, Saliva contamination, Rewashing, Re-etching, Bond strength.

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INTRODUCTION

Restorative dentistry is at the peak of the post-amalgam age, which is mainly based on composite resin. The key element in the success of composite resin is durability of the bond between composite resin and tooth structure.⁴ One of the major reasons of a poor or failed bond between composite resin and the etched enamel is saliva contamination of the etched enamel.^{11,12} Rubber dam isolation is routinely recommended for prevention of saliva contamination.^{2,12} However, a survey reported that only 5% of the dentists use rubber dam during routine operative procedures.^{6,7}

Some studies have demonstrated that only rewashing and drying of the etched and saliva contaminated enamel surface is effective in restoring bond strength to the normal ideal condition.^{3,9}

Hence, this study was undertaken to evaluate the effect of saliva contamination on the shear bond strength of composite resin to enamel by using different parameters.

MATERIALS AND METHODS

In this study, 50 freshly extracted human permanent molars free of caries, fractures and previous restorations were used. All three were then embedded in acrylic blocks up to cemento-enamel junction in steel molds.

The facial surface of each tooth was flattened with abrasive carborundum disks to form the bonding substrate. The prepared enamel surface of each tooth was covered with adhesive tape having a round hole, 3 mm in diameter to limit the surface area of etching. The uncovered enamel surface was etched for 15 seconds with 37% phosphoric acid gel, rinsed for 15 seconds. The teeth were then randomly divided into five groups each containing 10 teeth.

Control Groups

- *Group I (control group—dry):* Uncontaminated specimens.

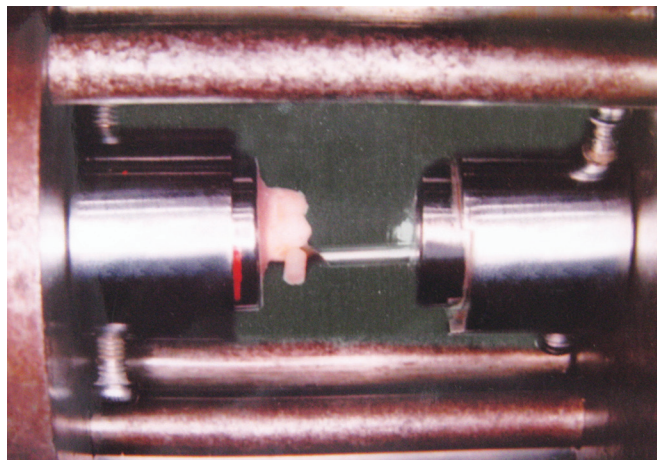


Fig. 1: Teeth with composite resin cylinder molds mounted on Hounsfield tensometer

- *Group II (control group—moist):* Etched enamel surface of each tooth in this group was moistened with wet cotton pellet for 10 seconds, before application of the bonding agent.

Experimental Groups

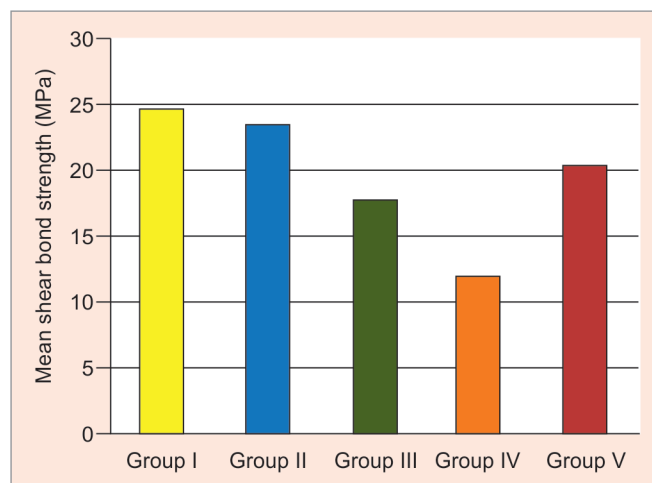
- *Group III:* Etched enamel surface of each tooth in this group was contaminated with natural saliva for 15 seconds and air-dried with a blast of oil-free air for 15 seconds before application of the bonding agent.
- *Group IV:* Etched enamel surface of each tooth in this group was contaminated with natural saliva for 15 seconds and left moist, before the application of bonding agent.
- *Group V:* Etched enamel surface of each tooth in this group was contaminated with natural saliva for 15 seconds, rinsed with water for 20 seconds and then air-dried with a blast of oil-free air for 15 seconds, before the application of the bonding agent.

Water-based adhesive agent, Scotchbond Multi-purpose (3M ESPE), was applied to the etched enamel surface and cured as per manufacturer's instructions. For composite resin application, plastic and transparent cylinder molds with a diameter of 2.80 ± 0.02 , and 4 mm length were placed on the prepared and etched enamel surfaces. Resin composite was adapted into each of these moulds and cured.

After preparation of specimens, all the teeth were stored in distilled water for 24 hours. The teeth were

Table 1: Descriptive analysis (mean shear bond strength and standard deviation for each group)

Groups	Sample size	Mean \pm SD (μ m)
I	10	24.529 ± 1.5693
II	10	23.414 ± 0.7283
III	10	17.608 ± 2.0333
IV	10	11.695 ± 2.2026
V	10	20.376 ± 1.9478



Graph 1: Comparison of mean shear bond strength between the groups (Group I: dry control group; group II: moist control group; group III: saliva contaminated and air-dried group; group IV: saliva contaminated moist group; group V: saliva contaminated, washed and air-dried group)

then mounted in Hounsfield tensometer (Fig. 1) with their surface enamel area parallel and flushing with the flat plane of the shearing blade. Loading was done until fracture occurred. Shear bond strength was calculated and noted for each tooth. Data obtained was then subjected to statistical analysis.

RESULTS AND OBSERVATIONS

The present *in vitro* study was conducted to evaluate the effect of saliva contamination on the shear bond strength of composite resin using different parameters.

The mean shear bond strengths and standard deviations for the five groups are shown in Table 1 and Graph 1. The findings of the present study were statistically analyzed by using ANOVA and unpaired t-test. Result of the statistical analysis revealed that the mean shear bond strengths of these five groups were highly statistically ($p < 0.001$) from each other (Table 2).

The comparison of the mean bond strength of the dry control group (group I) with the mean shear bond strength of the moist control group (group II) was done using the unpaired t-test. Result of statistical analysis revealed that there was no significant difference ($p > 0.05$) between the mean shear bond strengths of these two groups (Table 3). When the mean shear bond strengths of the control groups (groups I and II) was compared with

Table 2: ANOVA test

	Sum of squares	df	Mean square	F	p-value
Between groups	1058.723	4	264.681	83.903	0.0000*
Within groups	141.956	45	3.155		
Total	1200.680	49			

*The mean difference is highly significant ($p < 0.001$)

Table 3: Comparison of the experimental groups with the control group

Groups	t-value	p-value
I and II	2.038	0.057, NS
I and III	8.521	0.000*
I and IV	15.006	0.000*
I and V	5.250	0.000*
II and III	8.501	0.000*
II and IV	15.974	0.000*
II and V	4.260	0.000*

*The mean difference is highly significant ($p < 0.001$);
NS: Not significant

the mean shear bond strengths of the experimental groups (groups III, IV and V), highly significant differences ($p < 0.001$) were noted (Table 3). The experimental groups (groups III, IV and V) also showed highly significant difference ($p < 0.001$) when compared with each other (Table 4).

DISCUSSION

At present, composite resin has become a norm in restorative dentistry. Critical in the success of these composite resin restorations is the durability of the bond between composite resin and tooth structure. To achieve optimum bond strength, the tooth surface must be etched properly and be free of contaminants.^{5,10,11} One of the most common contaminant is saliva which reduces the bond strength between composite resin and the enamel by 40 to 50%.^{8,12,13}

Isolation is routinely recommended for prevention of contamination.^{1,12} Though rubber dam is ideal for isolation, it is not used by many dentists during routine operative procedures. Dentists prefer other methods of isolation which are not as effective as the rubber dam.^{6,7}

To restore the bond strength of the saliva contaminated enamel surface, it has been suggested by O'Brien et al⁹ and Bendrii Y et al³ that rewashing of the saliva contaminated enamel surface is enough, whereas others reported that rewashing of the saliva contaminated enamel surface is not sufficient.^{8,11}

In view of differences in opinion, this effort has been undertaken to evaluate the effect of saliva contamination on the shear bond strength of composite resin by using different parameters (Graph 1).

In this study, groups I (dry enamel surface) and II (moist enamel surface) showed mean shear bond strengths of 24.52 and 23.41 MPa respectively. When bond strengths of these groups were compared with each other, it was observed that they do not differ significantly ($p > 0.05$). This result suggests that the water-based bonding agent was equally effective on the dry and the moist enamel surface because of its hydrophilic nature.

Table 4: Comparison of the experimental groups with each other

Groups	t-value	p-value
III and IV	6.238	0.000*
III and V	3.109	0.006*
IV and V	9.336	0.000*

*The mean difference is highly significant ($p < 0.001$)

Comparable results were obtained in the studies done by Xie J et al¹³ and Bendrii Y et al.³ Mean shear bond strength values for dry and moist enamel surface were reported to be 19.9 ± 4.4 and 22.0 ± 1.3 MPa by Xie J et al, while the later reported values of 23.40 ± 1.85 and 20.15 ± 3.91 MPa for dry and moist enamel respectively.

Among the experimental groups (groups III, IV and V), group IV showed the lowest mean bond strength value (11.69 MPa). This value is in confirmation with the bond strength values reported by Hormati A et al,⁸ Xie et al¹³ and Bendrii Y et al³ who have reported bond strengths of 12.25 , 12.50 ± 2.5 and 9.30 ± 1.86 MPa respectively, for the saliva contaminated moist enamel surface.

Etching of enamel is used to achieve increased surface area. It also exposes reactive sites of calcium and phosphate ions resulting in high surface energy as well as increased wettability of the etched enamel surface.^{1,5,11} However, a thin film of organic pellicle formed due to saliva contamination results in lowered surface energy.^{5,11} The glycoprotein from the pellicle gets attached electrostatically to reactive site of the etched enamel. Coalescence of this glycoprotein with the monomer component of bonding agent may prevent adequate copolymerization of the bonding agent with the subsequently placed composite resin.¹³ The moisture from saliva additionally plugs the microporosities of the etched enamel surface.⁸ The cumulative effect of all the above factors may have resulted in significantly lower ($p < 0.001$) shear bond strength for group IV samples as compared with the control group samples (groups I and II).

Group III showed mean shear bond strength value 17.60 MPa which was intermediate to that of the other two experimental groups. This value is in confirmation with the values reported by Hormati A⁸ and Bendrii Y et al who have reported 20.83 and 18.52 ± 1.45 MPa bond strengths respectively, for the saliva contaminated air-dried enamel surface.

Samples of group III showed significantly lower ($p < 0.001$) mean shear bond strength than the control groups. This lowered mean shear bond strength value may be due to the mechanism of salivary glycoprotein. However, this value was greater than that obtained for group IV samples. This can be attributed to the fact that although air drying resulted in opening of microporosities of the etched enamel by removal of moisture,⁸ but it

was not able to remove the salivary glycoprotein film.¹³ This dried salivary glycoprotein film may have prevented the intimate contact between the bonding agent and the etched enamel surface.

Group V samples showed mean shear bond strength value of 20.57 MPa which was the highest among the experimental groups. O'Brien et al⁹ and Bendrii Y et al³ reported bond strengths of the saliva contaminated, washed and air dried enamel surface to be 16.20 ± 3.70 and 20.88 MPa respectively.

The high bond strength obtained for group V was due to the fact that it was washed and dried after saliva contamination. Rewashing of the saliva contaminated enamel surface may have partially removed the layer of salivary glycoprotein from the surface and resulted in increased permeability of the remaining precipitated protein layer.¹³ This action of rewashing may have facilitated the penetration of the bonding agent into the enamel porosities.

The high bond strength obtained for group V was significantly lesser ($p < 0.001$) than that of the control groups (groups I and II). This may be attributed to the fact that rewashing does not achieve complete removal of protein from the saliva contaminated enamel surface. These findings are in agreement with those of Hormati A et al⁸ and Silverstone L et al,¹¹ but not in agreement with O'Brien et al⁹ and Bendrii Y et al³ who stated that rewashing of the saliva contaminated enamel surface is sufficient to achieve adequate bond strength (Graph 1).

CONCLUSION

From this study, it can be concluded that saliva contamination of the etched enamel surface decreases its bond strength to composite resin. It is recommended that the

necessary precautions to achieve immaculate isolation should be taken to avoid saliva contamination during bonding procedure.

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