ORIGINAL RESEARCH

Effect of Air Drying on Shear Bond Strength after Contamination with Saliva and Blood

Ramkishore Ratre[1], Sandhya Jain[2], G. V. Kulkarni[1], Madhu Singh Ratre[3]

ABSTRACT

Objectives: The objective of this study was to study the effect of air drying after contamination with saliva and blood on shear bond strength (without decontamination) and debonding characteristics.

Materials and Methods: An *in vitro* study was performed taking 60 extracted human first premolars divided equally in three groups. Samples in Group A were bonded according to manufacturer instructions without contamination, in Group B, teeth were contaminated with 0.1 ml human saliva applied to the etched surface; the teeth were air dried then bonded with adhesive and primer. The teeth in Group C were contaminated with 0.1 ml fresh human blood applied to the etched surface; the teeth were air dried then bonded with adhesive and primer. Shear bond strength testing and adhesive remnant index (ARI) scores were performed.

Results: The differences in bond strengths and ARI scores between the groups were assessed by one-way ANOVA test and *post-hoc* Tukey test. Both the tests revealed statistically significant differences for bond strengths and ARI scores. Group A shows higher values for bond strength (13.86 megapascals [Mpa]) as compared with Group B (9.84 Mpa) and Group C (7.78 Mpa). Group A shows higher values for ARI (3.89) as compared with Group B (2.3) and Group C (0.7).

Conclusions: Saliva and blood contamination decreases the bond strength of composite resin adhesive after drying the contaminant.

Keywords: Acid etching, Blood contamination, Bond strength, Saliva contamination.

How to cite this article: Ratre R, Jain S, Kulkarni GV, Ratre MS. Effect of Air Drying on Shear Bond Strength after Contamination with Saliva and Blood. Int J Oral Care Res 2018;6(1):S36-40.

Source of support: Nil

Conflicts of interest: None

INTRODUCTION

The present-day "bonding," what we see today is the result of pioneering effort of Buonocore,[1] in 1955, who demonstrated the increased adhesion produced by acid pretreatment, using 85% phosphoric acid and Newman[2] for the 1st time began to apply these findings to direct attachment of orthodontic appliances.

Tooth surface acid etch bonding is a multistep procedure and each step is crucial to prevent bond failure. Strong interface between enamel and the resin can only be achieved when a tooth preparation procedure is followed correctly. It is crucial to have dry surfaces for bonding as saliva may affect the strength and setting process of composite resin.

In orthodontic practice, often, the bonding is done under difficult conditions of moisture and/or blood contamination which may affect the etched surface. Contamination of the tooth surface is likely to occur after the enamel is etched, before the bonding material is placed and may result from sudden spill of saliva from salivary gland or movement of the lips or tongue.

Contamination with moisture, saliva or blood during bonding can lead to early failure of the bond. Orthodontist and surgeons often collaborate in the exposure of unerupted teeth to apply orthodontic traction. There is a 50% decrease in bond strength in the presence of moisture.[3] It may be concluded that this was the result of saliva that deposited an organic adhesive layer within the first few seconds of exposure and was resistant to washing.[4]

Conventional composites that contain hydrophobic functional monomers, which have little affinity to enamel, do not give sufficient bond strength in cases when moisture control is impossible. Recently, moisture insensitive primer has been introduced to orthodontic profession, which maintains the bond strength in wet conditions. Sometimes, a reduction in the bond strength can lead to early failure of lingual bonded retainers or bonding on teeth with inflamed gingiva.

The purpose of this study was to investigate the effect of saliva and blood contamination on shear bond strength after drying the contaminated area (without decontamination). In the reported studies, bonding was done on the wet contaminated surfaces as well as when the surfaces have been blotted.[5] Some studies evaluate the influence of contamination and decontamination on bond strength.[6] In this study, while studying the effect of saliva and blood contamination, the surfaces

[1]Associate Professor, [2]Professor, [3]Reader

[1-3]Department of Orthodontics, Government College of Dentistry, Indore, Madhya Pradesh, India

Corresponding Author: Dr. Ramkishore Ratre, Department of Orthodontics, Government College of Dentistry, 1, Sardar Patel Road, Indore, Madhya Pradesh, India. Phone: +91-9425-070696/+91-731-2701808. e-mail: rkratre@yahoo.co.in

are dried again after contamination, as in the clinical situations, air blowing takes just few seconds to get rid of contaminant. Hence, this study investigates the effect of drying after contamination on the bond strength of composite resin material.

Aims and Objectives

This *in vitro* study was carried out to study the effect of saliva and blood contamination on shear bond strength, with the following aims and objectives:

1. The effect of saliva contamination on shear bond strength of orthodontic composite resin after drying the contaminant.
2. The effect of blood contamination on shear bond strength of orthodontic composite resin after drying the contaminant.

MATERIALS AND METHODS

A total of 60 sound human first premolars were collected (12–18 years) which were extracted for orthodontic purpose. Teeth with restorations, enamel defects, or cracking were excluded from the study. All teeth were stored in 37% formaldehyde for maximum of 6 months to inhibit bacterial growth. Teeth were randomly divided into three equal groups. Retentive groves were placed on the root portion of each tooth. Teeth were mounted in acrylic blocks. The buccal surfaces were cleaned with pumice and water slurry with a dental rotary toothbrush for 15 s, washed with water for 15 s. Etching was done with 37% phosphoric acid for 15 s and dried with air for 3 s.[7] Metal 0.018 brackets# were bonded with adhesive and primer and light cured for 40 s, as per the manufacturer's instructions.

Group A: The teeth in Group A were bonded under no contamination with adhesive* and primer, **as per the manufacturer's instructions.

Group B: The teeth in Group B were contaminated with 0.1 ml human saliva applied to the etched surface; the teeth were air dried then bonded with adhesive and primer.

Group C: The teeth in Group C were contaminated with 0.1 ml fresh human blood applied to the etched surface; the teeth were air dried then bonded with adhesive and primer.

- Gemini metal brackets; Unitek, *Adhesive - Transbond XT; 3M, **Primer - Transbond MIP; 3M Unitek, Monrovia, Calif).

All teeth were stored in distilled water at room temperature for 24 h. The acrylic blocks with teeth embedded were removed from water and allowed to dry for 5 min. The testing was done on "KMI tensile testing machine" (working within accuracy of –1% and +1% and is of Class 1 of IS: 1828 (Pt. I)–1991). The machine consists of two crossheads mounted on a frame; one of which moves away from the other. The acrylic block with the tooth sample was fixed on the lower crosshead. The sensitivity range of the testing machine is 0–500 Newtons. A stainless steel tie wire (23 gauge) was attached to the upper head. This tie wire was the one, kept constant for testing each specimen.

The crosshead speed was set to move away from each other at 5 mm/min. As the wire was engaged into the bracket slot and the crossheads allowed to move away from each other at the above-mentioned speed, the wire became firm and gradually became parallel to the bracket slot. The load was applied till the point of fracture, i.e., till the bracket detached itself from the tooth. The operator recorded load in Newtons. All the results obtained were tabulated, and the shear bonding strengths were calculated megapascals (Mpa) using the formula:

Shear bond strength (Mpa)=Breaking load (Newtons)/ Area of the mesh base (sq. mm.).

The shear bond strength equals to breaking load (in Newtons) divided by the area of the mesh base (in Sq. mm.).

Adhesive Remnant Index (ARI)

In addition, the surfaces of both the tooth and the bracket were examined to assess the ARI, which describes the amount of composite adhesive that remains on the surface of the tooth.[8]

ARI score 0: No remnant

ARI score 1: <1 third remnant

ARI score 2: More than one-third but less than two-third of remnant

ARI score 3: More than two-third but less than whole surface

ARI score 4: Whole surface is covered with adhesive, with distinct impression of the bracket mesh

All the data were subjected to statistical analysis using one-way analysis of variance (ANOVA) and *post-hoc* Tukey test.

RESULTS

The difference in bond strength and ARI score between the groups was assessed by one-way ANOVA test and *post-hoc* Tukey test. One-way ANOVA test revealed that the different bonding technique exhibits significant difference in bond strength [Table 1] and ARI score [Table 2]. *Post-hoc* Tukey test also revealed significant intergroup difference between groups (A-B, B-C, and A-C) for bond strength [Table 3] and ARI score [Table 4]. Group A showed higher values for bond strength (13.86 Mpa) as compared with other groups.

Table 1: One-way ANOVA test for shear bond strength in Mpa

Group	*n*	Mean	Standard deviation	Standard error	95% confidence interval for mean	
					Lower bound	Upper bound
Group A	20	13.86	1.99	0.45	12.93	14.80
Group B	20	9.84	2.06	0.46	8.88	10.80
Group C	20	7.78	1.67	0.37	7.00	8.56

ANOVA: *P*<0.000: Significant. Mpa: Megapascals

Table 2: One-way ANOVA test for ARI score

Group	*n*	Mean	Standard deviation	Standard error	95% confidence interval for mean	
					Lower bound	Upper bound
Group A	18	3.39	0.70	0.16	3.04	3.74
Group B	20	2.30	1.53	0.34	1.59	3.01
Group C	20	0.70	1.03	0.23	0.22	1.18

ANOVA: *P*<0.000: Significant. ARI: Adhesive remnant index

Table 3: *Post-hoc* Tukey test for shear bond strength

Intergroup Comparison	Group A	Group B	Group C
Group A		0.000	0.000
Group B	0.000		0.004
Group C	0.000	0.004	

Table 4: *Post-hoc* Tukey test for ARI score

Intergroup Comparison	Group A	Group B	Group C
Group A		0.014	0.00
Group B	0.014		0.00
Group C	0.00	0.00	

ARI: Adhesive remnant index

The bond strength of Group A is followed by Group B (9.84 Mpa) and Group C (7.78 Mpa).

There was a statistically significant difference between the adhesive remaining indices for each group. Group A shows higher values for ARI (3.89) as compared with other groups. The ARI of Group A is followed by Group B (2.3) and Group C (0.7).

DISCUSSION

Moisture control in the oral cavity is an ever-present problem, especially in certain patients or in particular areas of the mouth. Lots of studies have been done to find out the effect of moisture, saliva and blood contamination on shear bond strength in the wet conditions. The present study is undertaken to study the effect of saliva and blood contamination when the tooth surfaces are dried again after contamination.

In the present study, the Group A showed the bond strength of 13.86 Mpa and is comparable with the study of Hobson *et al*.[9] (MIP dry field - 15.69 Mpa), Klocke *et al*.[10] (MIP dry field - 15.07 Mpa), Schaneveldt and Foley.[11] (MIP dry field - 14.82 Mpa), Cacciafesta *et al.*[12] (MIP dry field - 12.76 Mpa), and Grandhi *et al*.[13] (MIP dry field - 10.14 Mpa). The specimen used in the study of Grandhi *et al*.[13] was bovine teeth and may provide a different force level compared to human teeth. In addition, the acid preparation of teeth significantly alters the morphologic conditions of enamel and may not resemble the human teeth. Theoretically, studies using human teeth could have different bond values from those using bovine teeth, but the results should show the same trend in different conditions. The study of Zeppieri *et al.*[14] showed the bond strength of 20.7 Mpa. The higher value might be due to dual curing procedure, i.e., first 10 s exposure of light on primer and after application of bonding material.

Littlewood *et al*.[15] found that the bond strength of hydrophilic primer was significantly lower than with conventional primer; however, the median bond strengths were promising. The difference in bond strength of control group of different investigators might be due to variability in proper fit between enamel surface and bracket, precisely placing the blade of machine, the bonding procedure, and no parallelism between direction of force and long axis of tooth.

The Group B showed significant difference in bond strength (9.84 Mpa) as compared to Group A. This trend of decrease of bond strength after contamination of saliva was also found in the study of Grandhi *et al*.[13] (8.90 Mpa), Zeppieri *et al*.[14] (15.0 Mpa), Klocke *et al*.[10] (14.91 Mpa), and Schaneveldt and Foley[11] (12.23 Mpa).

Grandhi *et al.* found a decrease in bond strength from 10.14 Mpa to 8.90 Mpa. However, the specimen used was bovine teeth. The decrease in bond strength was less than the present study. Results of Klocke *et al*. also followed the same trend of decrease in bond strength from 15.07 Mpa to 14.91 Mpa with bovine teeth. They used the indirect bonding technique and in case of bracket failure, adhesive was removed with finishing bur and rebonding was done. Results of Cacciafesta also followed the same trend of decrease in bond strength as in the present study from 12.76 Mpa to 7.56 Mpa on bovine teeth. The study of Zeppieri showed the decrease in bond strength as in the present study from 20.7 Mpa to 15.0 Mpa on human teeth. He did not dry the contaminated surfaces. Schaneveldt also found similar trend of decrease in bond strength from 14.82 Mpa to 12.23 Mpa. The results of Rangaswami and Sridevi showed only a slight decrease in the bond strength from 9.27 Mpa to 9.07 Mpa. In their study, they blotted the contaminated surface and left the surface moist.[5] This might be due to reduction in the quantity of contamination. It was suggested that the contamination of etched enamel by salivary proteins prevented monomers from penetrating the pores in enamel, which reduced the bond strength.[16] Microscopic examination of saliva contaminated acid-etched enamel showed the formation of an organic pellicle that could not be removed with water.[4] The organic pellicle coating masked the underlying enamel pores, decreased resin accessibility, and impaired mechanical adhesion. However, the contaminated enamel could be reconditioned by an additional 10 s of acid etching.[3] In the present study, the teeth were air dried after contamination then bonded with primer and adhesive, thereby showing the detrimental effect of drying saliva. This might be because of formation of firm layer of salivary protein on the tooth surface, which might have decreased the bond strength more than the previous studies where the bonding was done on the wet surface.

The Group C showed the significant difference in bond strength as compared with Group A. The mean bond strength in this group was 7.78 Mpa. The result of Cacciafesta *et al.*[17] found reduction in bond strength from 8.36 Mpa to 4.86 Mpa after light curing for 10 s on the mesial side and 10 s on the distal side. The lesser value of bond strength of control group (8.36 Mpa) and blood-contaminated group (4.86 Mpa) might be because of lesser curing time. Recommended light curing time is 40 s.[18] Bovine teeth were used in this study. The study of Hobson *et al*. showed bond strength of 11.16 Mpa when the tooth surface was contaminated with 0.1 mL of blood (MIP etch/dry - 15.69 Mpa and MIP etch/blood - 11.16 Mpa). In their study, they contaminated the tooth surface with blood and bonding was done on wet surface. In the present study, the surface was dried before applying the primer and a film of blood was formed. The decrease in bond strength from 13.86 Mpa to 7.78 Mpa which is slightly more decrease than the study of Hobson *et al*., which may be because of the formation of film of blood after drying the contaminated area.

There was a statistically significant difference between the adhesive remaining indices for each group. Group A showed higher values for ARI (3.89) as compared with other groups. The ARI of Group A was followed by Group B (2.3) and Group C (0.7).

ARI of Group B was 2.3 and Group C was 0.7, which was lesser than Group A and suggestive of lesser amount of adhesive remained on tooth surface after debonding possibly due to the formation of a film of saliva and blood after contamination was dried.

ARI score depends on many factors including the bracket base design and the adhesive type, and not simply on the bond strength at the interface.

The present study was undertaken to find out the effects of drying the contaminant on the bond strength. The research of *in vitro* testing of bond strength should be interpreted with care because many differences exist between the *in vitro* and *in vivo* testing conditions. Both the groups in this study show bond strength sufficient for clinical use. Reynolds[19] suggested that minimum bond strength of 6–8 MPa is adequate for most clinical orthodontic needs. These bond strengths are considered able to withstand masticatory and orthodontic forces. Considering this, it is suggested to have further clinical studies to evaluate the bond strength under these conditions.

CONCLUSIONS

This study was undertaken to evaluate the shear bond strength with saliva and blood contamination when the contaminated surfaces were air dried. Based on the recorded data and the statistical analysis, it was found that saliva and blood contamination decreases the bond strength of composite resin adhesive after drying the contaminant. The bond strengths of the contaminated groups seem to be sufficient for clinical use, but the results of *in vitro* study should be interpreted with caution and further clinical study is suggested.

REFERENCES

1. Buonocore MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. J Dent Res 1955;34:849-53.
2. Newman GV. Epoxy adhesives for orthodontic attachments: Progress report. Am J Orthod 1965;51:901-12.
3. Hormati AA, Fuller JL, Denehy GE. Effects of contamination and mechanical disturbance on the quality of acid-etched enamel. J Am Dent Assoc 1980;100:34-8.
4. Silverstone LM, Hicks MJ, Featherstone MJ. Oral fluid contamination of etched enamel surfaces: An SEM study. J Am Dent Assoc 1985;110:329-32.
5. Rajagopal R, Padmanabhan S, Gnanamani J. A comparison of shear bond strength and debonding characteristics of conventional, moisture-insensitive, and self-etching primers *in vitro*. Angle Orthod 2004;74:264-8.
6. Brauchli L, Eichenberger M, Steineck M, Wichelhaus A. Influence of decontamination procedures on shear forces after contamination with blood or saliva. Am J Orthod Dentofacial Orthop 2010 Oct;138(4):435-441.
7. Wang WN, Lu TC. Bond strength with various etching times

on young permanent teeth. Am J Orthod Dentofacial Orthop 1991;100:72-9.

8. Artun J, Bergland S. Clinical trials with crystal growth conditioning as an alternative to acid-etch enamel pretreatment. Am J Orthod 1984;85:333-40.
9. Hobson RS, Ledvinka J, Meechan JG. The effect of moisture and blood contamination on bond strength of a new orthodontic bonding material. Am J Orthod Dentofacial Orthop 2001;120:54-7.
10. Klocke A, Shi J, Kahl-Nieke B, Bismayer U. *In vitro* investigation of indirect bonding with a hydrophilic primer. Angle Orthod 2003;73:445-50.
11. Schaneveldt S, Foley TF. Bond strength comparison of moisture-insensitive primers. Am J Orthod Dentofacial Orthop 2002;122:267-73.
12. Cacciafesta V, Sfondrini MF, De Angelis M, Scribante A, Klersy C. Effect of water and saliva contamination on shear bond strength of brackets bonded with conventional, hydrophilic, and self-etching primers. Am J Orthod Dentofacial Orthop 2003;123:633-40.
13. Grandhi RK, Combe EC, Speidel TM. Shear bond strength of stainless steel orthodontic brackets with a moisture-insensitive primer. Am J Orthod Dentofacial Orthop 2001;119:251-5.
14. Zeppieri IL, Chung CH, Mante FK. Effect of saliva on shear bond strength of an orthodontic adhesive used with moisture-insensitive and self-etching primers. Am J Orthod Dentofacial Orthop 2003;124:414-9.
15. Littlewood SJ, Mitchell L, Greenwood DC, Bubb NL, Wood DJ. Investigation of a hydrophilic primer for orthodontic bonding: An *in vitro* study. J Orthod 2000;27:181-6.
16. Xie J, Powers JM, McGuckin RS. *In vitro* bond strength of two adhesives to enamel and dentin under normal and contaminated conditions. Dent Mater 1993;9:295-9.
17. Cacciafesta V, Sfondrini MF, Scribante A, De Angelis M, Klersy C. Effects of blood contamination on the shear bond strengths of conventional and hydrophilic primers. Am J Orthod Dentofacial Orthop 2004;126:207-12.
18. Wang WN, Meng CL. A study of bond strength between light- and self-cured orthodontic resin. Am J Orthod Dentofacial Orthop 1992;101:350-4.
19. Reynolds IR. A review of direct orthodontic bonding. Br J Orthod 1975;2:171-8.