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Research Article

Comparative Evaluation of Shear Bond Strength of Metallic Brackets With Two Bonding Agents With and Without Saliva Contamination

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Abstract

Objectives: The present study was carried out to compare the shear bond strength of metallic brackets bonded with single Bond and Assure bonding agents under dry and saliva contamination conditions.

Materials and Methods: A total 60 sound premolar teeth were selected for the purpose of this in vitro study and stainless steel brackets were bonded on enamel surfaces with single bond and assure bonding agents under a dry condition or with salivary contamination. The shear bond strength values of the brackets were measured in a universal testing machine. The adhesive remnant index (ARI) scores were determined after debonding of the brackets under a stereomicroscope. One-way ANOVA was used to analyze bond strength. Two-by-two comparisons were made with post hoc Tukey tests ($P < 0.001$). The frequencies of ARI scores were analyzed with Kruskal-Wallis test.

Results: The bond strength values of brackets to tooth structure were 9.29 ± 8.56 and 21.25 ± 8.93 MPa with the use of Assure resin bonding agent under saliva contamination and dry conditions, respectively. These values were 10.13 ± 6.69 and 14.09 ± 6.6 MPa, respectively, under the same conditions with the use of single bond adhesive. Contamination with saliva resulted in a significant decrease in the bond strength of brackets to tooth structure with the application of Assure adhesive resin ($P < 0.001$). There were no significant differences in the ARI scores between the different study groups.

Conclusions: Application of single bond and assure bonding agents resulted in adequate bond strength of brackets to tooth structures. Contamination with saliva significantly decreased the bond strength of Assure bonding agent compared to dry conditions.

Keywords: Shear Bond Strength, Assure Universal Bonding Resin, Single Bond Adhesive Resin

1. Background

A proper bond between the bracket and enamel is necessary for orthodontic treatment (1). Favorable shear bond strength is in a range to withstand oral and occlusal forces during treatment and at the same time it should be easy to debond the bracket at the end of treatment without inflicting any damages on the enamel. During the bonding process, there is always the risk of contamination of the etched surfaces with saliva. Contamination of enamel surfaces with saliva has been reported as one of the etiologic factors for bond failure (2). Conventional composite resins require a dry and contamination-free surface to achieve adequate bond strength; however, under clinical conditions, it is difficult to completely isolate the area in question against moisture during the bracket bonding procedure (3) and it is possible for the enamel surfaces to become contaminated during etching and after the application of primer (4). If the enamel surfaces are contaminated before the application of primer, the porosities produced due to the effect of the acid etching procedure will become occluded and the surface energy of the enamel will decrease, interfering with the penetration of resin tags, which will result in a decrease in micromechanical retention and finally in a decrease in the bond strength between the resin and the etched enamel (5, 6).

Assure universal bonding resin is a relatively new product with fluoride release properties. This bonding agent has been reinforced with a resin cement (7). This bonding agent has hydrophilic properties, does not need to be photo-activated and has the capacity to bond to light-cured or dual-cured adhesives. Assure hydrophilic resin system (Reliance, USA) has been evaluated under wet conditions in some cases and proper bond strength values have been reported under such conditions (3, 4, 8). It has been claimed that the bond strength of Assure adhesive agent is not affected by contamination with saliva (9).

2. Objectives

Therefore, the present study was undertaken to compare the sear bond strength values of metallic brackets bonded with the use of Single Bond and Assure bonding agents in order to determine a more reliable technique for bonding under dry conditions and contamination with saliva.

3. Materials and Methods

The present in vitro study was carried out on 60 sound human premolar teeth extracted for orthodontic reasons. The teeth had no carious lesions, fractures, cracks or abrasion. The teeth were stored in 0.2% thymol solution at room temperature before initiation of the study and between the various study procedures 10. The samples were randomly divided into 4 groups (n = 15) as follows:

1) Single Bond (3M ESPE) group under dry conditions

2) Single Bond group under contamination with natural saliva

3) Assure universal bonding resin (Reliance orthodontic products, Inc. USA) group under dry conditions

4) Assure universal bonding resin group under contamination with natural saliva

In all groups, the coronal buccal surfaces of the teeth were polished with fluoride-free pumice for 10 seconds, rinsed for 30 seconds and dried (10).

Ortho organizer company 0.22 standard metallic stainless steel brackets, with a base surface area of 11.8 mm^2, were bonded to tooth structures using different bonding protocols as follows:

1) In group 1, the buccal enamel surfaces of the teeth were etched with 37% phosphoric acid (3M Unitek) for 15 seconds, rinsed for 30 seconds (11) and dried with oil-free air stream so that a white chalky appearance of enamel was achieved. Then the single bond bonding agent (3M ESPE) was applied to the buccal surface in two layers, left undisturbed for 10 seconds to dry gradually and light-cured for 10 seconds using a Woodpecker light-curing unit (China). Then 3M Uritek composite resin was applied to the base of the brackets, followed by determining the exact position of the brackets. The brackets were pressed on the tooth surface to extrude extra composite resin from underneath the brackets. Extra composite resin was removed from the periphery of the bracket bases using a small dental explorer. Then the brackets were irradiated from the mesial and distal aspects for 20 seconds each. All the procedures were carried out according to manufacturers' instructions.

2) In group 2, all the etching, rinsing and drying steps were carried out based on the Single Bond protocol but before application of the bonding a thin layer of natural saliva was applied on the enamel surfaces 3. The saliva sample had been collected by the operator after cleaning the teeth and abstaining from eating for 1 hour. All the other procedures were similar to those in group 1.

3) In group 3, Assure universal bonding resin was used. All the etching, rinsing and drying procedures conformed to the Assure bonding agent application protocol. The bonding agent was applied in two layers on the buccal surface, left undisturbed for 10 seconds and dried gently. Then the composite resin was applied to the bracket bases and their positions on the enamel surfaces were determined carefully. The brackets were pressed on the enamel surfaces to extrude the extra composite resin to leave a minimum thickness of composite resin under the bracket. Extra composite resin was removed from the periphery of the brackets, followed by light-curing from the mesial and distal aspects for 20 seconds each.

4) In group 4, the teeth were etched, rinsed and dried. Before application of the Assure bonding agent, a thin layer of natural saliva was applied on the surface of the etched enamel. Then two coats of the Assure adhesive resin were applied on the buccal surface and left undisturbed for 10 seconds. The rest of the procedures were similar to those carried out and explained for group 3.

After the bonding procedures, all the samples were incubated at 37°C for one week. The samples were then subjected to a 100-round thermocycling procedure at 5 - 50°C, consisting of 30 seconds of dwell time and 15 seconds for transfer between water baths. In the next stage, a surveyor was used to mount the samples in an identical position so that the debonding force would be applied perpendicular to the tooth-bracket interface. An electromechanical universal testing machine (K-21046, Walter + bai, Switzerland) was used to apply shearing force with a preload force of 0.5 Newton at a crosshead speed of 1 mm/min to debond the bracket from the tooth surface. The debonding force was measured in Newton. Then the shear bond strength values were calculated in MPa by dividing force (N) by the cross-section surface area (mm).

After debonding, the samples were evaluated under a stereomicroscope at ×10 to determine ARI (adhesive remnant index) scores as follows:

0: no adhesive resin remaining on the composite resin

1: less than 50% of the adhesive resin remaining on the composite resin surface

2: more than 50% of the adhesive resin remaining on the composite resin surface

3: 100% of the adhesive resin remaining on the composite resin surface

Finally, 4 samples were randomly selected from each group for SEM evaluations. To this end, the samples were bisected using a diamond saw after measuring the shear bond strength values. One half was selected for the visualization of the contact surface. The sample surfaces were sputter-coated and underwent SEM evaluations to determine the bond failure modes and the quality of enamel destruction.

Two-way ANOVA was used to determine the effect of bonding agent and bonding conditions on the shear bond strength. One-way ANOVA was used to analyze differences in bond strength values with the use of two different bonding agents under dry and saliva-contamination conditions. Post hoc Tukey tests were used for two-by-two comparisons. Non-parametric Kruskal-Wallis test was use to compare the frequencies of different ARI scores between the 4 study groups. Statistical significance was set at $P < 0.0001$.

4. Results

Two-way ANOVA did not reveal any significant differences between the effects of bonding agent type on the shear bond strength of metallic brackets to tooth structures ($P = 0.12$). However, the effects of dry condition and salivary contamination on the shear bond strengths of brackets were significant ($P < 0.0001$). Table 1 presents the results of two-way ANOVA.

One-way ANOVA showed significant differences in shear bond strength values of metallic brackets to tooth structures in terms of single bond and assure bonding agents under dry and wet (contamination with natural saliva) conditions ($P < 0.0001$), with Assure bonding agent providing the highest bond strength under dry conditions and the lowest with contamination with saliva.

The results of post hoc Tukey tests showed significant differences in bond strength values of brackets to tooth structures between single bond bonding agent under saliva-contamination conditions and assure adhesive resin under dry and saliva-contamination conditions ($P < 0.001$). However, in other cases there were no significant differences between the groups. In general, the shear bond strength of metallic brackets under saliva-contamination conditions was higher than that under dry conditions.

Table 2 presents the ARI scores in different study groups. Kruskal-Wallis test did not demonstrate any significant differences in the frequencies of ARI scores between the different study groups ($n = 15$) ($P = 0.29$).

Figures 1 - 4 present the SEM photomicrographs of the effects of different bonding agents and bonding conditions on the quality of bracket bonds to enamel. As shown by the photomicrographs, contamination with saliva prevented complete penetration of resin tags into the enamel surface porosities and their obturation with the use of both bonding agents, resulting in a decrease in bond strength when contamination with saliva occurred (Table 1).

5. Discussion

One of the prerequisites for bonding of brackets to tooth structures is the provision of a dry environment by careful isolation of the tooth surface. Unfortunately such isolation is difficult, especially in the posterior area and is considered a clinical challenge for clinicians. Several methods have been suggested to solve this problem, including use of hydrophilic materials, the bond of which is not influenced or is influenced minimally by the environmental moisture (12, 13).

Based on the results of the present study, the effects of bonding agent type (single bond vs. assure universal bonding resin) on the shear bond strength of metallic brackets to tooth structure were not significant ($P = 0.12$); however, the effects of bonding conditions (dry and wet) on the bond strength of brackets were significant ($P < 0.0001$). In other words, the bond strength values of stainless steel brackets to enamel with the use of single bond adhesive (14.09 MPa in dry and 10.13 MPa with salivary contamination) and Assure resin bonding agent (21.25 MPa in dry and 9.29 with salivary contamination) were in the favorable range of bond strength to enamel. However, contamination with saliva resulted in a significant decrease in shear bond strength values of metallic brackets to enamel with the use of assure adhesive resin ($P < 0.001$), but such a decrease was not significant with the application of Single Bond adhesive agent. Although the bond strength with the application of Assure adhesive resin was significant with saliva contamination, the bond strength was in the favorable range.

Previous studies on the effects of contamination with saliva on the bond strengths of brackets have yielded different and in some cases contradictory results. While some researchers have reported an increase in bond strength after contamination with saliva (14-16), some others have reported either no decreases in bond strength after contamination with saliva (16) or have reported significant decreases after contamination (17). The differences in the results of studies might be attributed to the use of artificial or natural saliva or the amount of saliva used. On the other hand, the composition of saliva might be different based on the conditions of the test (18). In addition, the bonding technique, too, might affect the results of the bond strength test.

Assure adhesive resin is composed of biphenyl dimethacrylate (< 35%), hydroxyethyl methacrylate (< 20%) and acetone (< 80%). It has been formulated to

Table 1. The Shear Bond Strengths of Metallic Brackets to Tooth Structures With the Use of Different Bonding Systems and Conditions (MPa)[a]

Group	Mean ± SD	Std. error	95% Confidence Interval		Min MPa	Max MPa
			Lower bound	Upper bound		
Dry; Single Bond	14.09 ± 6.6	1.7	10.43	17.74	4.11	25.26
Wet; Single Bond	10.13 ± 6.69	1.7	6.43	13.84	2.43	20.7
Dry; Assure	21.25 ± 8.93	2.3	16.3	26.19	7.02	33.84
Wet; Assure	9.29 ± 8.56	2.2	4.55	14.02	1.63	29.1

[a](P < 0.001).

Table 2. The Frequencies of ARI Scores in Different Study Groups[a]

	Group			
ARI	**0**	**1**	**2**	**3**
Dry; Single Bond	0	8 (53.3)	4 (26.7)	3 (20.0)
Wet; Single Bond	5 (33.3)	10 (66.7)	0	0
Dry; Assure	2 (13.3)	8 (53.3)	3 (20.0)	2 (13.3)
Wet; Assure	5 (33.3)	8 (53.3)	1 (6.7)	1 (6.7)
Total (n = 60)	12 (20.0)	34 (56.7)	8 (53.3)	6 (10.0)

[a](P = 0.29).

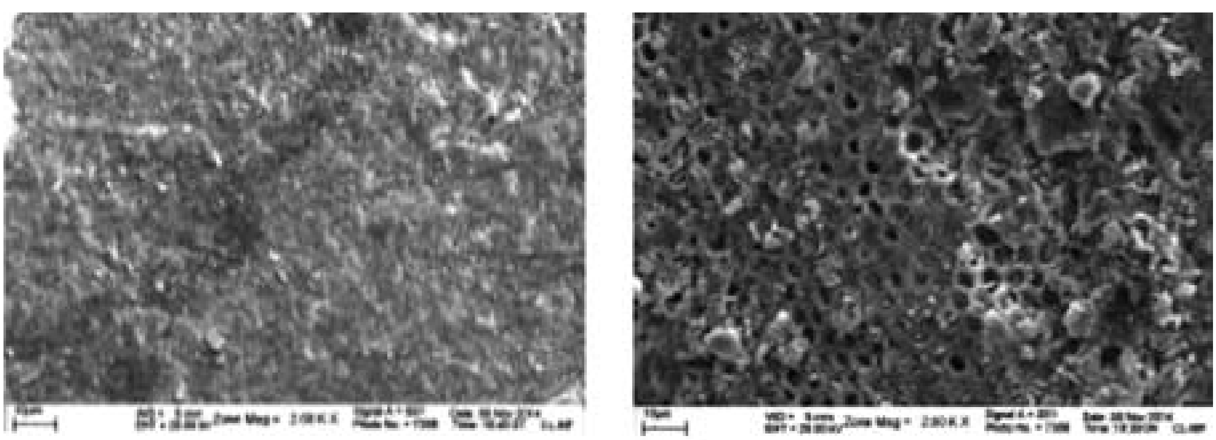

Figure 1. SEM Photomicrographs in the SINGLE Bond Group Under dry Conditions; Penetration of Resin Tags Into Enamel Porosities and Their Complete Obturation

improve adhesion to normal and abnormal enamel surfaces, hypocalcified dentin, surfaces with fluorosis and carious lesions and can bond to rough metallic surfaces and composite resin restorations without any need for the application of extra primers. With its application, contamination of enamel surfaces with saliva has no important role in decreasing the bond strength and it does not need photo-activation during the bonding procedure (except for dentin) (7); however, the results of the present study did not show any increase in the bond strength with contamination with saliva.

Conversely, in a study by Rix et al. (2001), no clinically significant differences were observed in shear bond strengths of brackets to enamel with the use of Assure adhesive resin under saliva-contamination conditions (9). In a study by Eslami Amirabadi et al. (2014), application of Assure adhesive resin to bond stainless steel brackets to enamel yielded adequate bond strength under dry condi-

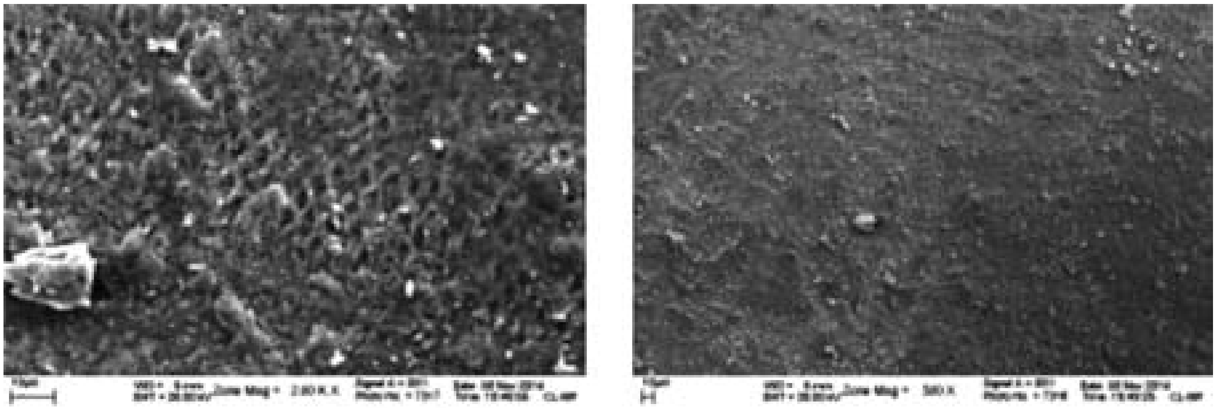

Figure 2. SEM Photomicrographs in the Single Bond Group in the Presence of Saliva Contamination; Partial Penetration of Resin Tags Into Enamel Porosities

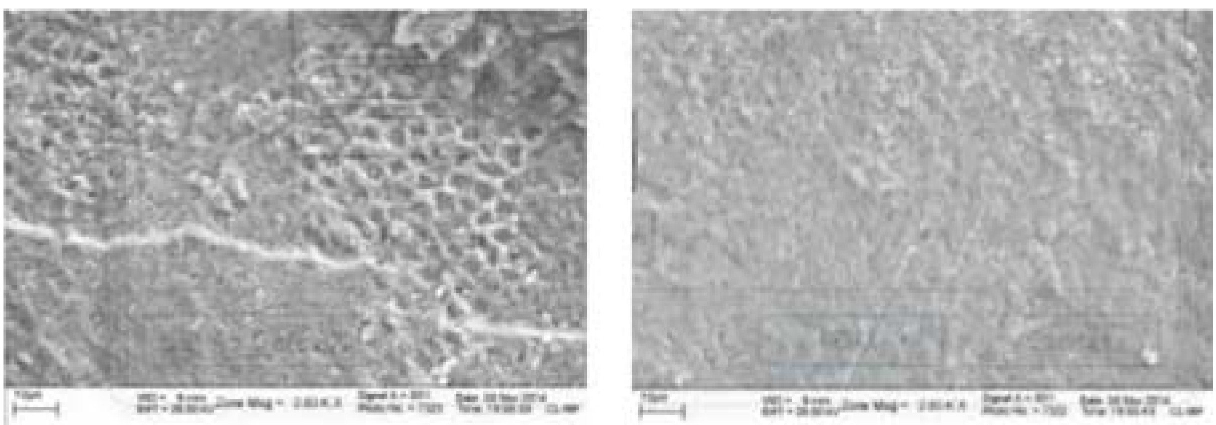

Figure 3. SEM Photomicrographs in the Assure Group Under dry Conditions; Penetration of Resin Tags Into Enamel Porosities and Their Complete Obturation

tions (mean = 14.18 MPa) and under contamination with saliva (mean = 13.32 MPa) (19). The bond strength values of the bond between the brackets and the enamel with the use of Assure adhesive resin under dry conditions in the present study (21.25 MPa) were higher than those in the study above but lower with saliva contamination (9.29 MPa) than those in the study above. In a study by Schaneveldt and Foley, too, the mean shear bond strength values of Assure adhesive resin were not influenced by contamination with saliva 4; however, such an observation was not made in the prevent study.

Based on the results of some studies the clinically acceptable range of shear bond strength for bonding of orthodontic brackets is 5.9 - 7.8 MPa (20-22). Therefore, both Single Bond and Assure bonding agents yielded adequate bond strengths to tooth structures under dry and wet conditions.

In a study by Eslami Amirabadi et al. application of Assure adhesive resin under dry and wet (contamination with saliva) conditions did not result in significant changes in shear bond strength values of orthodontic brackets to enamel (19). However, in the present study the shear bond strength of stainless steel brackets decreased significantly with the application of Assure adhesive resin with saliva contamination. However, the bond strength (9.29 MPa) was higher than the minimum bond strength necessary for bonding orthodontic brackets to enamel (5.9 MPa). Oztoprak et al. evaluated the effects of contamination with saliva on the bond strength of adhesive resis and reported that contamination with saliva resulted in a significant decrease in the bond strength of Assure adhesive resin, consistent with the results of the present study (14).

Bond strength values are under the influence of variables such as the tool used to measure bond strength, the

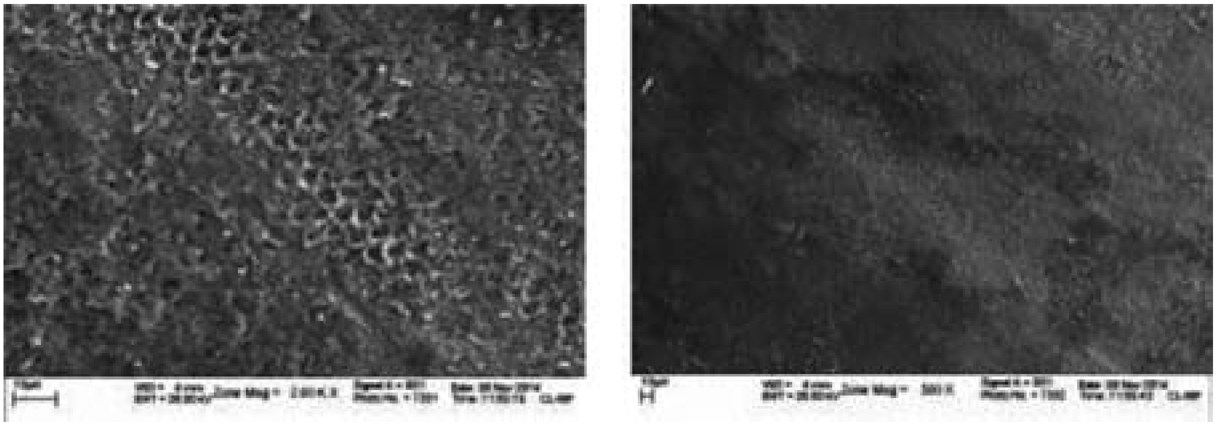

Figure 4. SEM Photomicrographs in the Assure Group in the Presence of Saliva Contamination; Partial Penetration of Resin Tags Into Enamel Porosities in Some Areas With Complete Penetration in Some Other Areas

type of the force applied to debond the brackets, the speed of the blade of the instrument, the type of the bracket and variations in the materials and methods (23).

In the present study, the bond strength values of stainless steel brackets with the use of single bond adhesive was at an acceptable level (14.9 MPa under dry conditions and 10.13 MPa with saliva contamination). SEM evaluations in the present study showed penetration of resin tags into the enamel porosities and their complete obturation with the application of both Single Bond and Assure bonding agents under dry bonding conditions; however, with saliva contamination in the assure group there was complete penetration in some areas and partial penetration in some other areas. In the single bond group, partial penetration of resin tags into enamel surface porosities was evident under salivary contamination.

Kanca et al. showed comparable bond strength with the application of dentin bonding agent on dry and wet enamel surfaces, with a little higher bond strength to wet enamel (24). Wakefielo et al. showed that moisture on the enamel surface does not decrease the bond strength with the use of dentin-bonding agents (25). In a study by Woronko et al (1992), absence or presence of moisture did not increase or decrease bond strength to enamel surfaces (26). Yasini and Malekan did not report any significant differences in bond strength values with dry and wet enamel (27), which is not consistent with the results of the present study.

In routine orthodontic procedures, it is important to achieve adequate bond strength for safe debonding rather than achieving maximum bond strength (28). The ARI scores have been used in various studies in order to determine the bond failure location in enamel, adhesive and bracket base by evaluating the amount of composite resin remaining on enamel surfaces. In the present study, no significant differences were observed in the frequencies of ARI scores between different study groups.

To prevent fractures or cracks on enamel surfaces it is favorable that failures occur within the resin (29); however, removal of the adhesive resin after debonding from tooth surfaces might be difficult and time-consuming, resulting in defects on the enamel surface. The adhesive should provide adequate bond strength and withstand orthodontic and masticatory forces; however, at the end of treatment, it should be removed easily so that the enamel would not be damaged. It appears other factors, too, might have a significant role in the ARI scores, including the bracket retention mechanism (30). Based on a report by O'Brien et al., the ARI scores depend on different factors, including the design of the bracket base and the type of the adhesive, and only the bond strength values do not affect ARI scores (31). On the other hand, ARI scores are determined visually, which might influence the results of studies in association with differences in the conditions of bond strength tests.

5.1. Conclusions

Application of Single Bond and Assure bonding agents might provide adequate bond strength during bonding of bracket to enamel surfaces. The bond strength of assure adhesive resin decreased significantly in the presence of saliva contamination compared to dry bonding conditions.

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References

1. Elekdag-Turk S, Turk T, Isci D, Ozkalayci N. Thermocycling effects on shear bond strength of a self-etching primer. *Angle Orthod.* 2008;**78**(2):351–6. doi: 10.2319/122906-537.1. [PubMed: 18251621].
2. Zachrisson BJ. A posttreatment evaluation of direct bonding in orthodontics. *Am J Orthod.* 1977;**71**(2):173–89. [PubMed: 319678].
3. 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**(4):414–9. doi: 10.1016/S0889540603004050. [PubMed: 14560272].
4. Schaneveldt S, Foley TF. Bond strength comparison of moisture-insensitive primers. *Am J Orthod Dentofacial Orthop.* 2002;**122**(3):267–73. [PubMed: 12226607].
5. Silverstone LM, Hicks MJ, Featherstone MJ. Oral fluid contamination of etched enamel surfaces: an SEM study. *J Am Dent Assoc.* 1985;**110**(3):329–32. [PubMed: 3889092].
6. 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**(2):264–8. doi: 10.1043/0003-3219(2004)074<0264:ACOSBS>2.0.CO;2. [PubMed: 15132455].
7. Reliance Orthodontic Products . Orthodontic Products 2016. Available from: http://www.relianceorthodontics.com/.
8. Webster MJ, Nanda RS, Duncanson MJ, Khajotia SS, Sinha PK. The effect of saliva on shear bond strengths of hydrophilic bonding systems. *Am J Orthod Dentofacial Orthop.* 2001;**119**(1):54–8. doi: 10.1067/mod.2001.109888. [PubMed: 11174540].
9. Rix D, Foley TF, Mamandras A. Comparison of bond strength of three adhesives: composite resin, hybrid GIC, and glass-filled GIC. *Am J Orthod Dentofacial Orthop.* 2001;**119**(1):36–42. doi: 10.1067/mod.2001.110519. [PubMed: 11174538].
10. Ruse ND, Shew R, Feduik D. In vitro fatigue testing of a dental bonding system on enamel. *J Biomed Mater Res.* 1995;**29**(3):411–5. doi: 10.1002/jbm.820290316. [PubMed: 7615591].
11. Murray SD, Hobson RS. Comparison of in vivo and in vitro shear bond strength. *Am J Orthod Dentofacial Orthop.* 2003;**123**(1):2–9. doi: 10.1067/mod.2003.49. [PubMed: 12532055].
12. Zacchrisson BJ. A post-treatment evaluation of direct bonding in orthodontics. *Am J Orthod Dentofacial Orthop.* 1977;**71**:173–89.
13. Eliades T, Brantley WA. The inappropriateness of conventional orthodontic bond strength assessment protocols. *Eur J Orthod.* 2000;**22**(1):13–23. [PubMed: 10721241].
14. Oztoprak MO, Isik F, Sayinsu K, Arun T, Aydemir B. Effect of blood and saliva contamination on shear bond strength of brackets bonded with 4 adhesives. *Am J Orthod Dentofacial Orthop.* 2007;**131**(2):238–42. doi: 10.1016/j.ajodo.2005.02.035. [PubMed: 17276865].
15. Sayinsu K, Isik F, Sezen S, Aydemir B. Effect of blood and saliva contamination on bond strength of brackets bonded with a protective liquid polish and a light-cured adhesive. *Am J Orthod Dentofacial Orthop.* 2007;**131**(3):391–4. doi: 10.1016/j.ajodo.2005.04.049. [PubMed: 17346596].
16. 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**(6):633–40. doi: 10.1016/S0889540603001987. [PubMed: 12806342].
17. Turk T, Elekdag-Turk S, Isci D, Cakmak F, Ozkalayci N. Saliva contamination effect on shear bond strength of self-etching primer with different debond times. *Angle Orthod.* 2007;**77**(5):901–6. doi: 10.2319/100906-415. [PubMed: 17902234].
18. 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**(2):181–6. doi: 10.1093/ortho/27.2.181. [PubMed: 10867075].
19. Eslami Amirabadi GR, Shirazi M, Shirazi Z. Effect of saliva contamination on shear bond strength of transbond xt and assure universal bonding resin to enamel. *J Islam Dent Assoc.* 2014;**26**(2):110–6.
20. Graber TM, Eliades T, Athanasiou A. Risk management in orthodontics: experts' guide to malpractice. *Br Dent J.* 2005;**198**:114–5.
21. Brantley WA, Eliades T. Orthodontic materials: scientific and clinical aspects. Thieme Stuttgart; 2001.
22. Reynolds IR. Letter: 'Composite filling materials as adhesives in orthodontics'. *Br Dent J.* 1975;**138**(3):83. [PubMed: 1089421].
23. Germec D, Cakan U, Ozdemir FI, Arun T, Cakan M. Shear bond strength of brackets bonded to amalgam with different intermediate resins and adhesives. *Eur J Orthod.* 2009;**31**(2):207–12. doi: 10.1093/ejo/cjn086. [PubMed: 19073953].
24. Kanca J3. Resin bonding to wet substrate. II. Bonding to enamel. *Quintessence Int.* 1992;**23**(9):625–7. [PubMed: 1287714].
25. Wakefielo CW, Sneed WD, Draughn RA, Davis TN. Composite bonding to dentin and enamel of humidity. *Gen Dent.* 1996;**44**:508–12.
26. Woronko GJ, St Germain HJ, Meiers JC. Effect of dentin primer on the shear bond strength between composite resin and enamel. *Oper Dent.* 1996;**21**(3):116–21. [PubMed: 9002871].
27. Yasini E, Malekan E. Comparison of shear bond strength between unfilled resin to dry enamel and dentin bonding to moist and dry enamel. *J Dent Med.* 2005;**18**(1):15–20.
28. Saito K, Sirirungrojying S, Meguro D, Hayakawa T, Kasai K. Bonding durability of using self-etching primer with 4-META/ MMA-TBB resin cement to bond orthodontic brackets. *Angle Orthod.* 2005;**75**(2):260–5. doi: 10.1043/0003-3219(2005)075<0256:BDOUSP>2.0.CO;2. [PubMed: 15825793].
29. Reynolds IR. A review of direct orthodontic bonding. *Br J Orthodont.* 1975;**2**:171–8.
30. D'Attilio M, Traini T, Di Iorio D, Varvara G, Festa F, Tecco S. Shear bond strength, bond failure, and scanning electron microscopy analysis of a new flowable composite for orthodontic use. *Angle Orthod.* 2005;**75**(3):410–5. doi: 10.1043/0003-3219(2005)75[410:SBSBFA]2.0.CO;2. [PubMed: 15898382].
31. O'Brien KD, Watts DC, Read MJ. Residual debris and bond strength–is there a relationship?. *Am J Orthod Dentofacial Orthop.* 1988;**94**(3):222–30. [PubMed: 3046329].