Comparison of Shear Bond Strength and Adhesive Remnant Index of Two Different Primers in Dry and Wet Conditions

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Abstract: *Purpose:* To assess the shear bond strength (SBS) and adhesive remnant index score (ARI) of different primers in dry condition and in wet conditions.

Materials and Methods: A total of 80 human premolars which are free from caries, cracks, and fine lines were collected and mounted on acrylic. These teeth were randomly distributed into two groups (Assure Plus and Transbond XT/MIP). Each group was again reassigned into two subgroups (dry and wet) with 20 teeth in each subgroup based on the primer used and enamel surface after etching (Contaminated or Non contaminated). All teeth bonded were then stored in separate glasses containing distilled water for seven days at 37 ^{0}C. Universal testing machine was used to measure the SBS by applying 50 kg of force at 0.5 mm/min. The adhesive remnant index was assessed by using a stereomicroscope.

Results: There is no statistically significant difference in shear bond strength of Assure plus and Transbond XT bonded in dry conditions. Among the four subgroups, Assure Plus on wet teeth showed the high bond strength (12.63 ± 6.64 Mpa). There is a statistically significant difference in ARI scores between Assure Plus and Transbond MIP bonded in wet conditions (P<0.001).

Conclusion: On moisture contaminated teeth, Assure Plus showed higher bond strength than Transbond MIP. Transbond MIP has the least bond strength among all, but the bond strength is adequate to withstand the masticatory forces.

Keywords: Shearbond strength, Adhesive remnant index, Transbond XT, Assure Plus, Transbond MIP.

INTRODUCTION

Until the 1960s, orthodontists used bands on all the teeth to treat malocclusions. *In vitro* orthodontic bonding using light cured materials was first described by Tavas and Watts [1]. Acid etching method developed by Bunocore [2] played a key role for the success of bonding procedures. Bond strength is the key factor to be considered in the development of new bonding materials. The material should be such that it tolerates the forces applied during the treatment period. There should be sufficient bond strength for an ideal orthodontic adhesive. The ideal characterestics of bond strength are adequate resistance to debonding during treatment, longevity, and low enough to remove the bracket from the tooth without causing damage to enamel and periodontium. According to Reynolds, 5.9–7.8 MPa resistances are sufficient to bear the occlusal forces [3]. In addition to bond strength, orthodontic adhesives should leave no to minimal resin behind in order to reduce damage to enamel while debonding. Adhesive Remnant Index (ARI), introduced by Artun and Bergland, is used to measure the amount of resin left behind after debonding.

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The presence of moisture contamination, from blood, saliva, and water, during bonding is responsible for bond failure [4]. These contaminats fill the porosities created by acid etching procedure, which results in decrease of the surface energy. This ultimately leads to reduced resin penetration with decreased number and length of resin tags [5, 6].

Bonding is severely affected by salivary contamination, because in the first few seconds of contamination, an organic adhesive coating is deposited which is resistant to washing. The effect of contamination on orthodontic bonding is due to weakening in the polymer network thereby releasing by-products such as formaldehyde, which are responsible for plasticizing effect [7]. In certain teeth such as molars and teeth that where impacted where it is hard to reach, it is beneficial to bond to enamel. Hydrophobic resins such as Conventional bisphenol A glycidyl methacrylate (BISGMA) resins are efficient only in a dry environment despite hydroxyl groups. Developing Moisture insensitive primers (MIP) are a solution to this problem.

Maintenance of a dry operating field and salivary control are the prime requisites of orthodontic bonding. Moisture control devices including saliva ejectors, salivary duct obstructers, anti-sialagogue tablets, and

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injections are used in routine orthodontic practice. However, in specific clinical situations such as bonding to surgically exposed teeth, partially erupted teeth, and bonding molar tubes on second molars, these aids are not adequate for moisture control [8, 9]. Few authors have reported a reduction in composite resin's bond strength to etched enamel after moisture and saliva contamination [10, 11]. To overcome this, some manufacturers introduced hydrophilic bonding materials, which can be used on moistened surfaces. Transbond Moisture Insensitive Primer (TMIP; 3M Unitek) and Assure Plus Primer (Reliance Orthodontic Products) were reported to have higher bond strength on saliva or water contaminated surfaces than conventional or hydrophobic system [12].

The components of Assure Plus, BisGMA (bisphenol A-glycidyl methacrylate) and ethanol, allow clinicians to successfully bond to metal, composite, and enamel (wet or dry; typical or atypical). Furthermore, Assure Plus is compatible with any light cure, dual-cure, and chemical cure paste regardless of manufacturer. Assure Plus adhesive agent has been claimed to be not affected by contamination with saliva [12]. Reliance Orthodontic Products introduced Assure Plus all surface Bonding Resin. .

The present study's purpose is to evaluate and compare the bond strength and Adhesive remnant index score of Assure Plus with two other conventional primers, Transbond XT and Transbond MIP.

MATERIALS AND METHODOLOGY

In this study, 80 human premolar teeth extracted for orthodontic reasons were collected. The sample teeth were examined to make sure of the absence of crack lines, dental caries or restorations. Then all the sample teeth were washed and then disinfected using 0.1% thymol solution for one week. The root of the teeth were mounted in self-curing acrylic resin so that the buccal surface of the teeth was parallel to the shearing force exerted by the blade of the instron device. 3M Unitek Gemini premolar brackets were used. Then the teeth were divided into two groups 40 teeth in each group. A single trained individual was trained to perform the bonidng procedure. A test bonding was performed separately to ensure proper adherence to the protocol. Each group was again divided to two sub groups with 20 teeth in each group. The groups were colour coded:

Group 1 a - Green (Assure dry)

Group 1 b - Brown (Assure wet)

Group 2 a - Blue (Transbond XT dry)

Group 2 b - Red (Transbond MIP)

In group 1 [G_1] (n=40) assure plus was used as the primer. In half of the groups G_1a (n=20), enamel was kept dry before bonding and in the other half G_1b (n=20), distilled water was applied and enamel surfaces were kept moist after etching and before bonding. In G_1a the buccal surfaces of the teeth were cleaned by a rubber cap and pumice, then washed for 10 seconds and dried. After wards they were etched with 37% phosphoric acid gel for 30 seconds, and were rinsed thoroughly with water and were dried with air spray until a frosty white surface was revealed. One coat of Assure plus was applied by brush on buccal surface and lightly dried with air to evaporate the solvent, the stainless steel bracket bases were coated with composite adhesive and placed at four-millimeters from the buccal cusp tip and pressed lightly in the position, then the extra composite was removed with a dental explorer and the adhesive was cured using a light curing unit for 20 seconds. In the other half (G_1b) distilled water was applied and enamel surfaces were kept moist after etching and before bonding using assure plus primer.

Group 2[G_2] (n=40) was again divided into two sub groups each containing 20 teeth. In G_2a (n=20) the buccal surfaces of the teeth were cleaned by a rubber cap and pumice, then washed for 10 seconds and dried. After wards they were etched with 37% phosphoric acid gel for 30 seconds, and washed out thoroughly with water and dried with air spray until a frosty white surface was revealed. Transbond XT primer was applied by brush on all surfaces and lightly dried with air to evaporate the solvent, the stainless steel bracket bases were coated with composite adhesive and placed at four millimeters from the buccal cusp tip and pressed lightly in the position, then the extra composite was removed with a dental explorer and the adhesive will be cured using a light curing unit for 20 seconds. In G_2b (n=20) distilled water was applied and enamel surfaces were kept moist after etching and before bonding using moisture insensitive primer. Then both groups were proceeded with application of composite resin on bracket base and was cured using a light curing unit.

Following the bonding of brackets, the specimens was stored in separate jars in distilled water for 7 days prior to the shear bond test. Shear bond strength (SBS) was measured using a universal testing machine by application of 50 kgf of force at 0.5 mm/min. The force

was exerted to the bonding site while the bracket base was parallel to the direction of force. Shear bond strength was measured in Newton, which was converted into Megapascals(Mpa) by dividing the shear bond force (Newton) by the bracket base area (mm^2). The adhesive remnant index and type of damage will be assessed by using stereomicroscope. Scores were given according to Artun and Bergland [13] scoring method.

Score 0 = No adhesive left on the tooth.

Score 1 = Less than half of the adhesive left on the tooth.

Score 2 = More than half of the adhesive left on the tooth.

Score 3 = All adhesive left on the tooth, with distinct impression of the bracket mesh.

Statistical analysis is carried out using power analysis software .G* power 3.192.

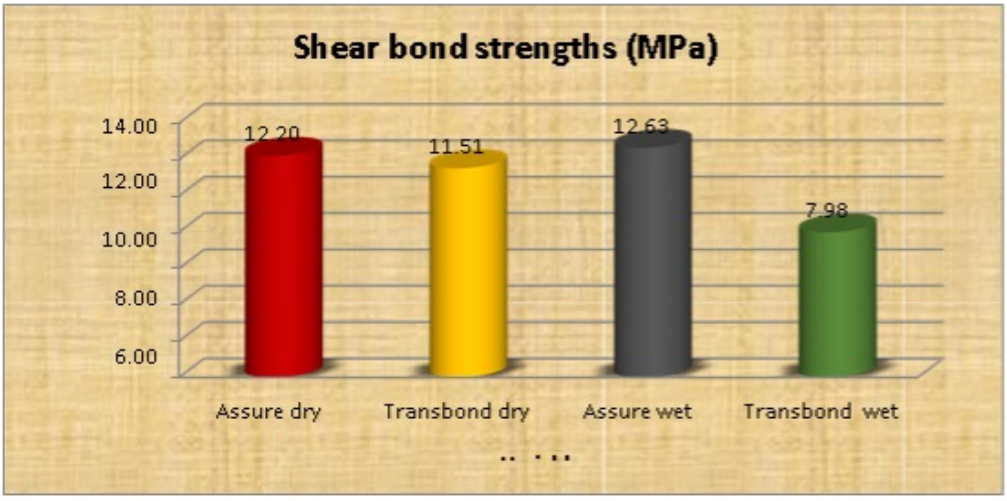
STATISTICAL ANALYSIS

Power analysis software G* power 3.192 is used for statistical ananlysis. To compare the mean shear bond strength between two independent groups unpaired t test was used. To compare the mean ARI scores between the two independent groups Chisquare test was used. Significance was set at P<0.05.

RESULTS

Graph **1** shows the mean comparison of shear bond strength (in MPa) of the four groups. Among the groups, G1b (Assure Plus on wet teeth) showed the high bond strength (12.63 ± 6.64 Mpa), followed by G1a (Assure Plus on dry teeth / 12.20 ± 5.47 Mpa), G2a (Transbond Dry / 11.51 ± 6.10 Mpa). G2b (Transbond MIP on wet teeth) showed the least bond strength (7.98 ± 7.23 Mpa) among the four subgroups.

Table **1** compares the shear bond strength of teeth bonded with Assure plus and Transbond primers in dry condition and Assure plus and Transbond MIP in wet conditions using the Independent sample T-test. There is no statistically significant (p < 0.071) difference in shear bond strength of Assure plus and Transbond primers bonded in dry conditions. On contrary, the bond strength of Assure Plus is significantly (p <0.04) higher than Transbond primer in wet conditions.

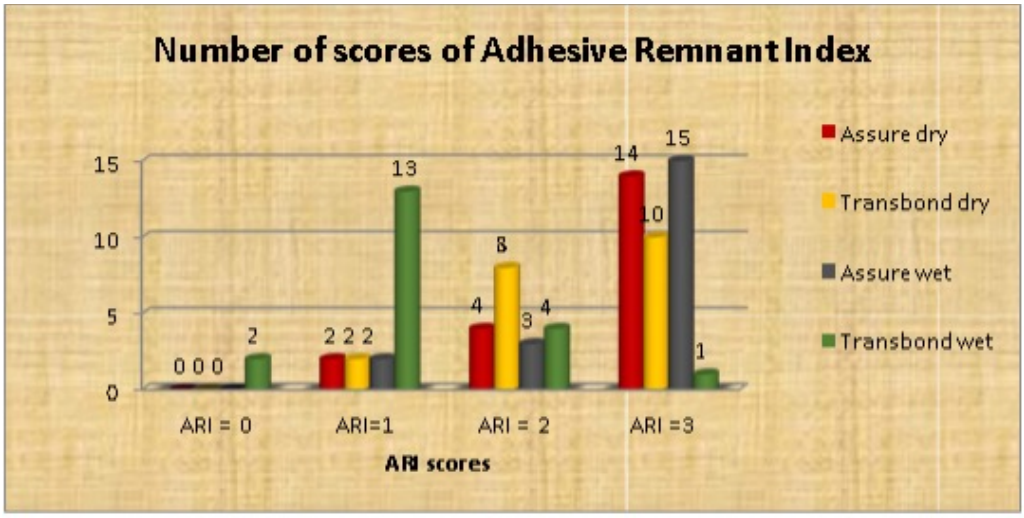


Graph 1: Depiction of Mean comparison of Shear Bond Strength among four sub-groups (G1a, G1b, G2a, G2b).

Table 1: Mean Comparison of Shear Bond Strength of Assure Plus and Transbond Primers Bonded in Dry and Wet Conditions

Comparing groups		t value	P value
Assure dry (G1a)	Transbond dry (G2a)	0.373	0.711
Assure wet (G1b)	Transbond wet (G2b)	2.116	0.041*

Independent sample t test. *Statistically significant if P<0.05.



Graph 2: Depiction of the Number and Frequency of ARI scores of 4 Subgroups.

Graph **2** shows the Number and Frequency of ARI scores of 4 Subgroups. Assure wet (G1b) has the highest ARI score, followed by Assure Dry (G1a) and Transbond dry (G2a). Transbond MIP (G2b) has the least ARI score. This shows that Transbond MIP has the least adhesive remnants on the tooth surface following debonding.

Table **2** compares ARI scores of different groups bonded in dry and wet conditions using a Chi-Square test. The P-value is 0.368, which shows no statistical significance between the two groups in dry conditions. P<0.001, which indicates that there is a significant difference in ARI scores between two groups bonded in wet conditions.

DISCUSSION

The provision of a dry environment by isolation of the tooth surface is a prerequisite for bonding brackets to tooth structures. A challenge for clinicians is isolation and bonding onto the posterior teeth. In this study, Assure Plus showed highest bond strength in wet condition, thereby being a choice of primer in hard to isolate areas.

Mehmet *et al*. [14], in his *in vitro* study, used incisors for measuring SBS, whereas Corel and McInnes *et al.* [15] used molars. In this study, premolars were used after reviewing few studies conducted by Fajen *et al* and Mc court *et al.* [16, 17]. According to Fox *et al.* [18], to get valid conclusions from an *in vitro* bond strength testing, there should be a minimum of 20, if possible 30 specimens per test. So, 40 teeth per group with 20 teeth in each subgroup were taken.

So, in order to reduce the bias, stainless steel pre-adjusted premolar brackets without hook were preferred and its use has also been favored by Meehan *et al*. [19] and Rix *et al*. [12]. In the current investigation, collected teeth were stored in distilled water with 0.1% (weight/volume) thymol. This storage medium inhibits the bacterial growth, maintains the teeth hydration level and does not alter the tooth surface's properties. Cacciafesta *et al*. [20], Hajrassie, and Khier [21] have used the same storage medium for their studies. Study by Eliades and Brantley [22] have reported that use of chemicals such as peroxides, glutaraldehyde, or normal saline should be avoided as they could alter enamel properties which may lead to biased results. In the present study, water is used for contamination after etching and before priming under wet conditions.

Table 2: ARI Scores Comparison between the Groups in Dry and Wet Conditions

Comparing groups		Chi- square test value	P value
Assure dry (G1a)	Transbond dry (G2a)	2.000	0.368
Assure wet (G1b)	Transbond wet (G2b)	22.460	<0.001*

Chi- square test. *Statistically significant if P<0.05.

However, research by Prasad *et al*. [23] has shown that when compared with water, blood and saliva have the most influence on the bond strength. In the current study, the mean shear bond strength of Assure plus in wet condition (G1b) 12.63 Mpa was greater than Transbond MIP in wet condition (G2b) 7.98 Mpa. This is because Assure Plus was less influenced by salivary contamination than were the other products. Assure Plus in its composition has MDP monomer which allows bond to both enamel and dentin chemically and ethanol in the primer enhances the bond to enamel [24]. Ethanol displaces moisture from the isolated enamel surface. However study by Grandhi *et al.* [25] found that MIP and Transbond XT produced acceptable bond strength (9.69 MPa and 8.90 MPa), even with salivary and water contamination. Similar results were obtained in the current study in which the shear bond strength of MIP (7.98 Mpa) was less when compared with the other subgroups; however, the bond strength was of the acceptable range. In the present study, Assure plus had the high shear bond strength. However Rix *et al*. [12] and Schaneveldt and Foley [26] got contradictory results where he found that the bond strength of Assure adhesive along with its primer was lower than that of Transbond XT adhesive with its primer.

Even though Transbond MIP (G2b) in contaminated fields yielded lower shear bond strengths of 7.98 MPa when compared with Transbond XT (G2a), Assure Dry (G1 a) and Assure wet (G1 b), the four groups showed clinically acceptable bond strengths that are well above the recommendations given by Reynolds [3] . The clinical advantage of this is, under ideal moisture situations Transbond XT adhesive along with its primer can be used instead of Assure as it provides similar bond strength. However, in patients with moisture contamination, it seems that the clinician would benefit from using Assure plus primer as it has high bond strength when bonded in wet conditions. ARI scores have been used in various studies to determine the bond failure location. It is evaluated by measuring the amount of composite resin remaining on enamel surfaces. It is favorable to have bond failures occur within the resin to prevent enamel fracture. However, it might be difficult and time-consuming to remove the adhesive resin after debonding from tooth surfaces, which further results in defects on the enamel's surface. In this study, the range of ARI scores demonstrated that Transbond MIP with water contamination after the etch (G2b) had the lowest ARI score due to the primer and composite's hydrophobic properties. This result is similar to the study by Nemeth *et al*. [27]. According to O'Brien *et al*. [28] the amount of excess composite may not be related to bond strength but is decided by many other factors such as design of the bracket base and the properties of adhesive. By contrast, these Adhesive Remnant index scores are determined visually, which might influence the results of studies in association with differences in bond strength tests' conditions.

Kumaraswamy anandh *et al*. [29] concluded high ARI scores were seen in teeth bonded in a dry environment. In contrast, low ARI scores were seen if the brackets were bonded to the teeth that were contaminated with natural saliva or saliva substitute. This might be due to incomplete penetration of primer on the etched surfaces due to the presence of organic and inorganic substrates in saliva. These results were similar to that of this study's results, in which Transbond MIP has the least ARI score in wet conditions compared with Assure plus and Transbond XT in dry and wet conditions. Under dry conditions, Assure plus (G1a) has a high ARI score than the Transbond Dry (G2a). This result's clinical significance is that more adhesive remnants are found in Assure plus groups in both dry and wet conditions due to their high bond strength. More cleaning is needed for Assure plus groups, which may be associated with loss of enamel during Clean-up procedures. In the Transbond group, Transbond XT had high ARI scores, and Transbond MIP had the least ARI scores.

These results were similar to the results obtained by Juliana Fernandes de Morais *et al*. [30] in which they concluded that Transbond XT left significantly more adhesive remnants on the tooth surface. So, more clean up procedures are to be done for Transbond XT.

LIMITATIONS OF THE STUDY

- Generalization of *in vitro* findings should be cautiously applied to clinical scenarios as oral environment varies from patient to patient due to various habits.
- In the present study for wet contamination, water is used after etching and before priming. However, some studies [14] report that blood, saliva, and saliva substitutes give the best mimic for oral environment contamination than water.
- In the present study, samples are stored in distilled water for seven days before shear bond strength assessment. However, the thermal cycling of the specimens to assess the longevity of the bond was advised by buonocore [31].

- ARI score is subjective and depends on the individual ranking of the score

CONCLUSIONS

- There is no statistically significant difference in shear bond strength of Assure plus and Transbond XT bonded in dry conditions.
- On contamination with water, assure plus showed higher bond strength when compared with Transbond MIP.
- Transbond MIP has the least bond strength among all, but the bond strength is adequate to withstand the masticatory forces.
- Due to its high bond strength, Assure plus had a high amount of Adhesive remnants on the tooth surface, which needs cleaning procedures, which may further lead to enamel loss.
- Least Adhesive Remnants are found with Transbond MIP, which is statistically significant.

CONFLICTS OF INTEREST

Authors of the study report no conflicts of interest.

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