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Shear Bond Strength of Orthodontic Eyelets Bonded with a Self-Adhesive Moisture-Tolerant Resin Cement Under Isolation and with Blood and Saliva Contamination

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ABSTRACT

Objectives: Bonding of orthodontic attachments to enamel is essential in orthodontic treatment. This study aimed to assess the shear bond strength (SBS) of orthodontic eyelets to the enamel surface using a moisture-resistant self-adhesive resin cement under isolation in comparison with saliva and blood contamination.

Materials and Methods: This in vitro experimental study used 78 sound human premolars extracted for orthodontic purposes. Brackets were bonded to the teeth with either Transbond XT or Embrace WetBond in isolated conditions and also in presence of blood and saliva contamination. The samples were subjected to thermocycling, and then the SBS of the eyelets attached to the enamel was measured in each group. The adhesive remnant index (ARI) was also determined under a stereomicroscope. Data were analyzed by two-way ANOVA, Tukey's test, and Kruskal-Wallis test (alpha=0.05).

Results: The SBS of Transbond XT group was significantly higher than Embrace WetBond group under isolation and contamination with saliva and blood (P=0.000). In both adhesives, the SBS under isolated conditions was significantly higher than that in presence of blood and saliva contamination (P=0.000). There was a significant difference between the isolation and blood and saliva contamination groups regarding the ARI scores (P<0.05).

Conclusion: Transbond XT adhesive yielded a stronger bond than WetBond Embrace in both situations; however, it appears that Embrace WetBond can also provide satisfactory results and minimize enamel damage during debonding.

Keywords: Blood; Dental Cements; Saliva; Shear Strength

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INTRODUCTION

Successful bonding of orthodontic brackets and attachments to tooth enamel is imperative in orthodontic treatment [1, 2]. The type, composition, and curing mode of adhesives, duration of etching, concentration of etchant, bracket base design, force application mechanism, and testing environment are among the variables that affect the bond strength of brackets to the enamel surface [3]. The bond strength of orthodontic brackets to the enamel surface should be strong enough to resist the applied forces to prevent debonding. At the same time, it should not be too strong to allow safe debonding upon completion of treatment with no damage to the enamel surface. According to Zachrisson [4], contamination is one of the main causes of orthodontic bond failure.

Surgical exposure of impacted teeth and subsequent orthodontic treatment to bring them into the dental arch is a common practice [5]. In such circumstances, the bond strength of brackets is greatly reduced due to contamination with saliva, blood, water, and gingival crevicular fluid [6].

Resin cements are commonly used in dentistry. However, due to the inherent sensitivity of their constituents (Bis-GMA and bisphenol A) to moisture, their application might be associated with some problems [7]. Resin cements have undergone recent advancements, resulting in their relative resistance to moisture. Embrace™ WetBond™ cement (Pulpdent, Watertown, MA, USA) is a unique resin cement with no Bis-GMA or bisphenol which uses hydrophilic chemical resins [8]. This cement contains bi-, three-, and multi-functional acrylate monomers and a network of co-monomer acidic resins (mono-, di-, and tri-functional methacrylate monomers, barium, glass, ytterbium tri fluoride, inert minerals) that are activated by moisture [9, 10]. This cement is radiopaque and resistant to moisture. The Embrace WetBond cement releases fluoride, is dual-cure, and forms a chemical bond to the enamel, dentin, precious and non-precious metals, ceramics, composites, and fiber posts. This cement does not require bonding, although a bonding procedure can be used. Concerning dentin, no etching is required; however, the enamel should be etched [11].

In light of the introduction of new materials and the existing disparities in the data, this study aimed to compare the shear bond strength (SBS) of orthodontic eyelets bonded to tooth enamel using EmbraceTM WetBondTM cement with Transbond XT composite and assess the effects of saliva, blood, and moisture contamination.

MATERIALS AND METHODS

The Institutional Ethics Committee of Tehran University of Medical Sciences approved the protocol of this in vitro study (IR.TUMS.DENTISTRY.REC.1399.010).

Preparation of the samples:

Based on the results of Robaski et al, [28] the minimum sample size needed for each of the six study groups was calculated to be 12 using two-way ANOVA Power Analysis of PASS 11, taking into account α=0.05, β=0.2, mean standard deviation of SBS equal to 29.7 megapascal (MPa), and effect size=0.46.

A total of 78 human premolar teeth that had been extracted for orthodontic purposes were collected. The teeth were inspected under a stereomicroscope (SZX9; Olympus, Japan) at ×10 magnification to exclude teeth with cracks, decalcification, softening, and fractures. The soft tissue residues attached to the tooth surface were also removed. Following extraction, the tooth samples were stored in distilled water in a refrigerator at 4ºC until the experiment. There was a maximum of 3-month interval between the tooth collection process and the tests. The teeth were immersed in 0.5% chloramine T solution (Merck, Germany) for the purpose of disinfection for one week. The tooth surfaces underwent prophylaxis before initiating the tests using a rubber cup (Diadent, South Korea), fluoride-free pumice paste (Cina, Iran), and water for 10 seconds to remove all contaminants from the tooth surface. A new rubber cup was used for every five teeth. To ensure absence of structural flaws or enamel cracks, the buccal surface of each tooth was inspected by transillumination under a stereomicroscope (SZX9; Olympus, Japan) at ×10 magnification. Each tooth was then mounted in an acrylic block (Acropars, Iran) such that 2mm of the root surface remained exposed, and the buccal surface was oriented perpendicular relative to the horizontal line both mesiodistally and buccolingually.

Study groups:

A table of random numbers was used to divide the teeth into six groups (n=13):

Group 1: Bonding with Transbond XT (3M Unitek, Monrovia, CA, USA) adhesive under isolation

Group 2: Bonding with Embrace WetBond (Pulpdent Corporation, Watertown, MA, USA) cement under isolation

Group 3: Bonding with Transbond XT adhesive with saliva contamination

Group 4: Bonding with Transbond XT adhesive with blood contamination

Group 5: Bonding with Embrace WetBond cement with saliva contamination

Group 6: Bonding with Embrace WetBond cement with blood contamination

The teeth in each group were bonded in accordance with the guidelines provided by the manufacturer. The eyelets (3M Unitek, USA) were bonded parallel to the tooth's longitudinal axis at the middle of the clinical crown.

In group 1, the teeth were etched with 37% phosphoric acid (Ultradent, USA) for 20 seconds, rinsed and dried. After etching, each tooth had a chalky white appearance. Next, a microbrush was used to apply Transbond XT primer (3M Unitek USA), which was then light-cured for 10 seconds at an intensity of 800mW/cm^2 using a LED curing unit (Woodpecker, China). The base of the eyelet, which was positioned in the middle of the buccal surface of the tooth crown, was covered with Transbond XT (3M Unitek, USA) composite resin. The eyelet was then pressed to the buccal surface using a scaler to evenly reduce the cement thickness in each sample. Before light-curing, an eyelet surveyor was used to adjust the eyelet parallel to the horizontal line mesiodistally. Each eyelet was light-cured for 20 seconds on each side.

In group 2, similar to group 1, the teeth were etched to create a chalky white appearance. Following the attachment of the eyelet to the tooth surface, Embrace WetBond resin cement was applied to the base. The eyelet was light-cured for 20 seconds on either side.

Etching in group 3 was done similar to group 1. After 10 seconds, a soft air stream from the air syringe was used to remove 1 mL of natural saliva that had been applied on the tooth's buccal surface with a microbrush. Similar to group 1, the eyelet was bonded to the tooth surface using Transbond primer and composite resin.

Group 4 underwent the same etching process as group 1 before applying 1mL of blood on the tooth's buccal surface, which was subsequently removed using a soft stream of air from the air syringe. As in group 1, the eyelet was bonded to the tooth surface using Transbond XT primer and composite resin. The eyelet was light-cured for 20 seconds on each side.

In group 5, the etching process was the same as that in group 1. Next, a microbrush was used to apply 1mL of natural saliva on the buccal surface of the tooth. After 10 seconds, the saliva was removed by gentle air stream of the air syringe. Embrace WetBond resin cement was used to bond the eyelets followed by light curing of each side for 20 seconds.

Etching in group 6 was done similar to group 1. Next, 1mL of blood was applied on the buccal surface of each tooth, and then air sprayed with moderate stream of air from the air syringe. Embrace WetBond resin cement was then used to bond the eyelets to the tooth surface, followed by light curing of each side for 20 seconds.

The saliva sample was collected from one of the authors one hour after toothbrushing and refraining from eating, and right before the test. Fresh blood was collected from the finger of one of the authors after the area was disinfected with a cotton swab dipped in alcohol. The finger was punctured with a sterile needle and one drop of blood was collected and directly applied on the designated spot. After 10 seconds, a gentle air stream was directed toward the area from an oil-free air syringe for 5 seconds.

After positioning the eyelet in the middle of the buccal surface of the teeth in each group, extra cement was scraped off using a dental explorer. A LED curing unit (Woodpecker, China) was used to light-cure the gingival, occlusal, distal, and mesial aspects for 20 seconds at an intensity of 800mW/cm^2.

Thermocycling:

Following a 24-hour storage in distilled water at 37°C, the samples were subjected to 5000 thermal cycles between 5°C-55°C with a dwell time of 15 seconds and a transfer time of 10 seconds [12]. One sample from each group (6 samples in total) underwent interface evaluation under a scanning electron microscope (SEM, JSM-7600F; JEOL, Japan)

SBS testing:

An electromechanical universal testing machine (K-21046; Water+Bai, Switzerland) was used to measure the samples' SBS at a strain rate of 1mm/min in order to debond the eyelets. To apply force along the tooth's longitudinal axis, the device’s blade was positioned at the enamel-eyelet interface. The buccal surface was perpendicular to the acrylic resin surface during the mounting process. The eyelets were positioned mesiodistally parallel to the acrylic resin base during the bonding process. Furthermore, the operator could adjust the force direction buccolingually to apply the force appropriately.

Determination of adhesive remnant index (ARI) score:

With the exception of teeth that underwent interfacial inspection, the ARI score was calculated for each group using a stereomicroscope at ×10 magnification. The amount of adhesive left on the enamel was used to calculate the ARI score as follows (Fig. 1):

0: No adhesive remaining on the tooth surface

1: Less than 50% of adhesive remaining on the tooth surface

2: More than half of the adhesive remaining on the tooth surface

3: All the adhesive remaining on the tooth surface [13]

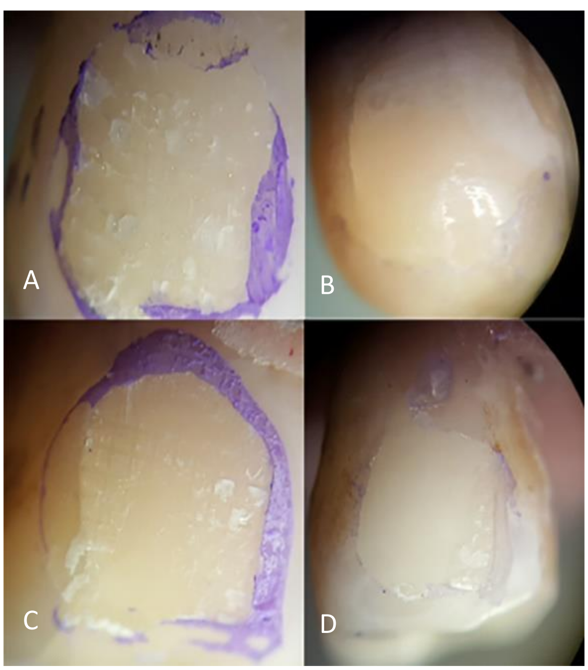

Fig 1. Different ARI scores under a stereomicroscope at ×10 magnification (A: 3, B: 0, C: 2, D: 1)

Due to normal distribution of data as confirmed by the Shapiro-Wilk test, the effects of cement type and condition (contamination/isolation) on SBS were analyzed using two-way ANOVA, followed by pairwise comparisons with the Tukey’s test. Additionally, the ARI scores were compared among the study groups using the Kruskal-Wallis test. Type I error was set at $\alpha=0.05$.

RESULTS

The descriptive statistics for the SBS in each of the six study groups are shown in Table 1. The Transbond XT group exhibited the highest SBS. Isolation condition yielded the highest SBS values for both adhesives, followed by saliva contamination, and then blood contamination. In all three conditions, Transbond XT yielded a SBS higher than Embrace WetBond. The highest SBS was recorded for Transbond XT under isolated condition (mean value of 30.33MPa). The lowest SBS (mean value of 13.96MPa) was recorded in Embrace WetBond under blood contamination.

Since the data were distributed normally, two-way ANOVA was used to compare the mean SBS values among the study groups (Table 2). The results showed that cement type ($P=0.003$) and contamination ($P=0.0001$) significantly affected the SBS. However, the interaction effect of cement type and contamination was not significant on SBS. In other words, changes in environmental conditions did not affect the difference in SBS between the adhesives ($P=0.315$).

Pairwise comparisons:

The post-hoc Tukey’s test was used for pairwise comparisons of the groups (Table 3). The results showed that the SBS of both cements under isolated condition was significantly higher than the values under blood and saliva contamination ($P=0.000$). However, the SBS of the eyelets to the enamel surface using each adhesive was not significantly different under blood and saliva contamination conditions ($P=0.132$).

The Transbond XT cement exhibited a significantly higher SBS than Embrace WetBond under all tested conditions ($P<0.001$). Blood and saliva contamination resulted in a significant decrease in SBS compared to the isolation condition with both cements. Contamination with blood was associated with a lower SBS than contamination with saliva with both cements; however, the difference was not significant (Table 3).

ARI scores:

Both cements showed significant differences in the frequency of ARI scores between the isolated and contaminated (with blood and saliva) groups (P=0.007). In other words, under the isolated condition, both Transbond XT and Embrace WetBond groups exhibited ARI scores of 2 and 3, indicating cohesive failure. However, there were no significant differences between the contaminated groups, with a zero ARI score in most cases (adhesive failure). Table 4 presents the ARI scores in each study group.

SEM observations:

SEM observations showed that in the contaminated groups, the cement and tooth did not come into contact compared to the isolated groups. In fact, contamination prevented the formation of micro- and macro-tags (Figs. 2 and 3).

Table 1. Measures of central dispersion for the SBS (MPa) in the study groups

Bonding	Environment	Minimum (MPa)	Maximum (MPa)	Mean±SD (MPa)
Transbond XT	Isolated	21.91	39.94	30.33±5.57
	Saliva	9.29	39.99	20.80±8.65
	Blood	2.48	22.93	15.57±5.83
Embrace WetBond	Isolated	16.25	30.73	23.25±4.58
	Saliva	6.79	22.97	15.77±4.68
	Blood	4.61	28.41	13.96±7.09

SD: Standard deviation, SBS: Shear bond strength, MPa: Megapascal

Table 2. Tests of between-subject's effects

Dependent Variable	Type lll sum of Squares	df	Mean Square	F	P value
Corrected Model	2302.024a	5	460.405	11.842	0.000
Intercept	28654.584	1	28654.584	737.033	0.000
Bonding agent	377.209	1	377.209	9.702	0.003
Condition	1833.369	2	916.685	23.578	0.000
Bonding agent-condition interaction	91.446	2	45.723	1.176	0.315
Error	2565.969	66	38.878		
Total	33522.577	72			
Corrected Total	4867.933	71			

Table 3. Pairwise comparison of the study groups regarding the SBS (MPa) using the Tukey's test

Compared conditions		Mean Difference (I-J)	Std. Error	P value	95% Confidence	
					Lower Bound	Upper Bound
Isolated	saliva	8.5038*	1.79996	0.000	4.1880	12.8195
	blood	12.0204*	1.79996	0.000	7.7046	16.3362
Saliva	isolated	-8.5038*	1.79996	0.000	-12.8195	-4.1880
	blood	3.5167	1.79996	0.132	-0.7991	7.8324
Blood	isolated	-12.0204*	1.79996	0.000	-16.3362	-7.7046
	saliva	-3.5167	1.79996	0.132	-7.8324	0.7991

Based on observed means; *The mean difference is significant at 0.05 level, SBS: Shear bond strength, MPa: Megapascal

Table 4. Frequency of different Adhesive remnant index (ARI) scores in the study groups

Cement	Condition	Category	ARI score 0	1	2	3	Total
Transbond XT	Isolated	Number	8	2	0	2	12
		percentage	66.6	16.6	0	16.6	100
	Saliva	Number	11	1	0	0	12
		percentage	91.6	8.3	0	0	100
	Blood	Number	12	0	0	0	12
		percentage	100	0	0	0	100
Embrace Wetbond	Isolated	Number	1	1	5	5	12
		percentage	8.3	8.3	41.6	41.6	100
	Saliva	Number	12	0	0	0	12
		percentage	100	0	0	0	100
	Blood	Number	12	0	0	0	12
		percentage	100	0	0	0	100

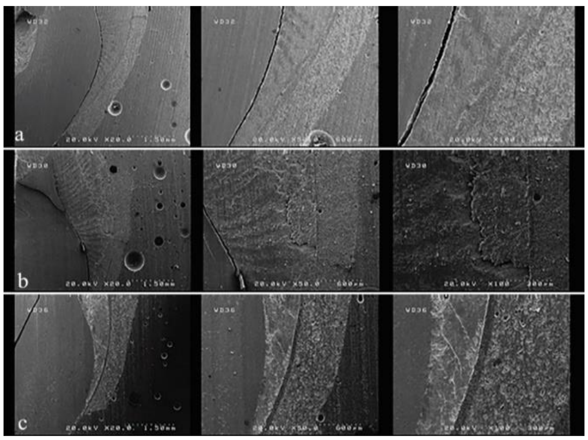

Fig 2. SEM micrographs of Transbond XT adhesive under isolation (a), with saliva contamination (b), and with blood contamination (c) at ×20, ×50, and ×100 magnifications

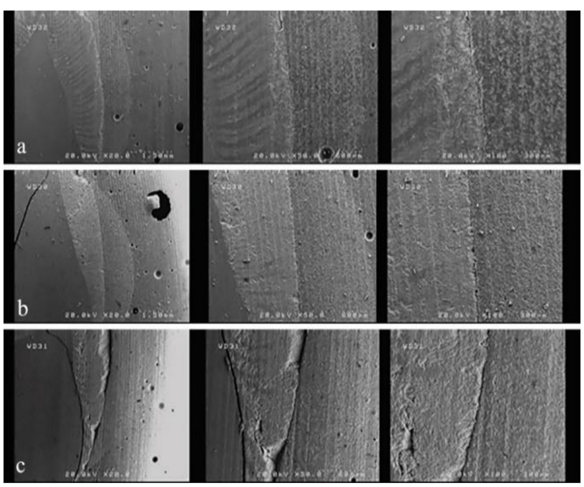

Fig 3. SEM micrographs of Embrace WetBond adhesive under isolation (a), with saliva contamination (b), and with blood contamination (c) at ×20, ×50, and ×100 magnifications

DISCUSSION

The occlusion of acid-etched porosities and lower surface energy caused by enamel surface contamination might hinder the penetration of resin tags into microporosities, reducing the quantity and size of resin tags as well as the bond strength [14]. There has been conflicting research in the past regarding how saliva affects the bond strength of brackets. Nonetheless, several research findings have aligned with the current investigation [15]. According to some researchers, contamination had no effect on bond strength [16], with some reporting even increased bond strength [17]. Such discrepancies might be attributed to the use of artificial or natural saliva, amount of saliva used, composition and pH of the saliva, differences in bonding techniques, and tooth type (human, bovine, etc.) [18, 19].

In a similar study, Sharifi et al. [12] reported a significant decrease in bond strength in the Transbond XT group after contamination with saliva. In their study, similar to the present study, in both groups with and without saliva contamination, the bond strength of Transbond XT was significantly higher than that of self-adhesive group; however, it should be noted that the adhesive type was different (Vertise Flow composite). According to a study by Ratre et al, [19] contamination with blood and saliva significantly reduced the bond strength, which is consistent with the current investigation. But in contrast to the current study, there was a notable difference between the blood and saliva groups. Safar Ali et al. [20] found that moisture contamination considerably reduced the bond strength, which is in line with the current investigation. Comparable to the current study's Transbond XT group without contamination (30.33MPa), the mean bond strength in the group of Transbond™ MIP without contamination was 28.5 MPa. In the study by Sharifi et al, [12] the bond strength in the Transbond XT group under the isolated condition was comparable to the value in the present study (26.63MPa vs. 30.33MPa).

Consistent with the present study, Evangelina et al. [21] used resin-modified glass-ionomer, Transbond MIP, and Transbond XT. They reported that contamination with saliva and blood significantly decreased the bond strength in the resin-modified glass-ionomer group. In addition, the differences between the blood and saliva groups were significant. However, in the Transbond MIP group, contamination did not significantly decrease the bond strength. Different adhesives were used in their study. Similar to the present study, natural blood was used in their study; however, unlike the present study, they used artificial saliva.

Consistent with the present study, Hafez and Nassar [13] reported a significant decrease in bond strength after contamination with blood. However, unlike the present study, contamination with saliva had no significant effect. Different adhesives were used in their study compared with the present study. The discrepancies in the results of studies on contamination with blood and saliva might be explained by differences in the composition of saliva and blood in different individuals, use or no use of anticoagulants, the natural or artificial nature of the saliva or blood, and the method used to collect saliva and blood samples [22, 23].

Similar to the present study, in a study by Khanehmasjedi et al, [24] contamination with saliva significantly decreased the bond strength in the hydrophilic adhesive group (Assure/Universal Bonding). However, in the Single Bond adhesive group, the difference was not significant. Different adhesives were used in their study. In studies by Maia et al, [25] and Sfondrini et al, [26] contamination with blood significantly decreased the bond strength. However, it should be noted that different adhesives were used in their study. Unlike the present study, in the study by Maia et al, [25] bovine incisors were used.

The enamel is more susceptible to damage in adhesive failure; however, less adhesive remains on the enamel surface. Therefore, less time would be required to polish the tooth. However, in cohesive failure, more adhesive remains on the tooth, leading to less damage during the attachment debonding. Nevertheless, more time and care are necessary for adhesive removal to avoid damaging the tooth.

Concerning the ARI scores, in the present study, scores 2 and 3 were more frequent under the isolated condition, indicating cohesive failure. However, with blood and saliva contamination, score ‘0’ was the most prevalent, indicating adhesive failure. The present study in this line is consistent with studies by Shaik et al, [27] Robaski et al, [28] Khanehmasjedi et al, [24], Güngör et al, [29] and Sfondrini et al [26]. In a study by Ratre et al, [19] similar to the present study, the ARI scores under isolated conditions were higher than those in groups with blood and saliva contamination. In their study, there were significant differences between the blood and saliva contamination groups, with higher ARI scores in the group with saliva contamination. In a study by Safar Ali et al, [20] the ARI scores of different study groups did not differ significantly, with the score ‘0’ prevailing under isolation and contamination conditions.

In the present study, the SBS of Transbond XT cement was higher than that of Embrace WetBond cement under all conditions. However, considering the composition of Embrace WetBond cement, based on the manufacturer’s claims, a higher bond strength was expected with this cement than with Transbond XT cement under blood and saliva contamination conditions.

Considering the different bonding

mechanisms of enamel and dentin, this cement appears to be more effective for bonding to dentin under moisture contamination. In addition, this cement exhibits a higher bond strength under dry conditions than under environmental contamination with moisture. Two possible mechanisms are involved. First, the wet bonding mechanism to enamel with hydrophilic monomers is associated with failure because moisture interferes with the formation of microtags. In addition, etched enamel has a higher surface energy than etched dentin and absorbs moisture rapidly. Therefore, an adhesive containing an alcohol or acetone solvent can displace this moisture and create a proper bond [28]; these solvents are present in Transbond XT bonding agent (primer). Under dry conditions, Transbond XT is more effective than Embrace WetBond because hydrophobic monomers that are polymerized at a higher degree create a higher bond strength with Transbond XT than with Embrace WetBond. Water sorption by hydrophilic monomers occurs at a higher rate, and higher water sorption accelerates the degradation mechanisms, resulting in structural defects at the bonding interface after immersion in water and thermocycling [30-32].

Since the acceptable range for the bond strength of bracket to enamel is 6-8 MPa, the bond strength in all the groups in the present study was within the normal range. The SBS values achieved in the present study were different from those in studies by Knaup et al, [33] Shaik et al, [27] and Ratre et al [19]. In these studies, the moisture-resistant groups showed a greater bond strength than the control group in saliva or blood contamination, which might be attributed to the equipment used to determine the bond strength, type of the applied force, the crosshead speed, presence or absence of thermocycling, bracket type, and differences in adhesive agents. Zeppieri et al. [34] cured the primer separately, which resulted in a higher bond strength.

Since the present study was carried out in vitro, it was not possible to accurately simulate the oral conditions, including the masticatory forces and occlusion. In addition, the teeth were collected from individuals of different ages. Semi-erupted teeth in young individuals might exhibit lower bond strength due to the presence of prismless enamel. Finally, although in vitro studies provide valuable data, clinical studies are necessary to better evaluate the materials and their behaviors under different clinical conditions.

CONCLUSION

Under the limitations of this in vitro study, the results showed that Embrace WetBond cement appears to provide sufficient SBS for brackets under dry and saliva contamination conditions. Concerning the ARI scores, score ‘0’ prevailed under blood and saliva contamination conditions, indicating adhesive failure. In such failure, enamel undergoes more damage. Considering the higher SBS of Transbond XT cement, it appears that applying Embrace WetBond cement will result in less enamel damage during bracket debonding.

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CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Abdelnaby YL, Al-Wakeel Eel S. Effect of early orthodontic force on shear bond strength of orthodontic brackets bonded with different adhesive systems. Am J Orthod Dentofacial Orthop. 2010 Aug;138(2):208-14.
2. Newman GV. Epoxy adhesives for orthodontic attachments: progress report. Am J Orthod. 1965 Dec;51(12):901-12.
3. 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 Mar;119(3):251-5.
4. Zachrisson BJ. A posttreatment evaluation of direct bonding in orthodontics. Am J Orthod. 1977 Feb;71(2):173-89.
5. Trakyali G, Oztoprak MO. Plant extract ankaferd blood stopper effect on bond strength. Angle Orthod. 2010 May;80(3):570-4.
6. Sfondrini MF, Cacciafesta V, Scribante A, De Angelis M, Klersy C. Effect of blood contamination on shear bond strength of brackets bonded with conventional and self-etching primers. Am J Orthod Dentofacial Orthop. 2004 Mar;125(3):357-60.
7. Feigal RJ, Hitt J, Splieth C. Retaining sealant on salivary contaminated enamel. J Am Dent Assoc. 1993 Mar;124(3):88-97.
8. Panigrahi A, Srilatha KT, Panigrahi RG, Mohanty S, Bhuyan SK, Bardhan D. Microtensile Bond Strength of Embrace Wetbond Hydrophilic Sealant in Different Moisture Contamination: An In-Vitro Study. J Clin Diagn Res. 2015 Jul;9(7):ZC23-5.
9. D'Alpino P, Araújo R, González A, Hipólito V, Valduga CJ, Dos Santos D, et al. Inorganic characterizations and filler particles morphology of self-adhesive cements. Int J Adhes Adhes. 2016 Jul;68:62-9.
10. Ku J, Lee J, Ra J. In Vitro Evaluation of Microleakage and Penetration of Hydrophilic Sealants Applied on Dry and Moist Enamel. J Korean Acad Pediatr Dent. 2017 Aug;44:272-9.
11. D'Alpino PH, da Rocha Svizero N, Carrilho M. Self-adhering composites .Dental Composite Materials for Direct Restorations: Springer; 2018. p. 129-51.
12. Sharifi N, Mohammadi Z, Arab S, Shojaee M, Vafadoost F, Zakerzadeh A. Shear Bond Strength of Orthodontic Brackets Bonded with a Self-Adhering Composite in Dry and Saliva-Contaminated Conditions. Front Dent. 2022 Jan 25;19:5.
13. Hafez AM, Nassar EA. The effect of saliva and blood contamination on the bond characteristics of metal bracket bonded by light cured cyanoacrylate adhesive. Egypt Dent J. 2018 Jan;64(1):69-75.
14. BUONOCORE MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. J Dent Res. 1955 Dec;34(6):849-53.
15. Tiwari A, Shyagali T, Kohli S, Joshi R, Gupta A, Tiwari R. Effect of Dental Chair Light on Enamel Bonding of Orthodontic Brackets Using Light Cure Based Adhesive System: An In-Vitro Study. Acta Inform Med. 2016 Oct;24(5):317-321.
16. Bishara SE, Khowassah MA, Oesterle LJ. Effect of humidity and temperature changes on orthodontic direct-bonding adhesive systems. J Dent Res. 1975 Jul-Aug;54(4):751-8.
17. Santos BM, Pithon MM, Ruellas AC, Sant'Anna EF. Shear bond strength of brackets bonded with hydrophilic and hydrophobic bond systems under contamination. Angle Orthod. 2010 Sep;80(5):963-7.
18. Tavas MA, Watts DC. Bonding of orthodontic brackets by transillumination of a light activated composite: an in vitro study. Br J Orthod. 1979 Oct;6(4):207-8.
19. Ratre R, Jain S, Kulkarni G, Ratre MS. Effect of Air Drying on Shear Bond Strength after Contamination with Saliva and Blood. Int j oral care res. 2018;6(1):40-36 .
20. Safar Ali ZNJ, Geramy A, Heidari S, Ghadirian H. Shear bond strength of APC Plus adhesive coated appliance system to enamel in wet and dry conditions: An in vitro study. Int Orthod. 2021 Mar;19(1):130-136.
21. Evangelina IA, Hambali T, Thahar B, Salim J. Comparison of shear bond strength of light-cured resin-modified glass ionomer and moist insensitive primer on contaminated enamel. IOP Conf Ser Mater Sci Eng. 2019;550:012040.
22. Prasad M, Mohamed S, Nayak K, Shetty SK, Talapaneni AK. Effect of moisture, saliva, and blood contamination on the shear bond strength of brackets bonded with a conventional bonding system and self-etched bonding system. J Nat Sci Biol Med. 2014 Jan;5(1):123-9.
23. 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 Feb;131(2):238-42.
24. Khanehmasjedi M, Naseri MA, Khanehmasjedi S, Basir L. Comparative evaluation of shear bond strength of metallic brackets bonded with two different bonding agents under dry

conditions and with saliva contamination. J Chin Med Assoc. 2017 Feb;80(2):103-108.
25. Maia SR, Cavalli V, Liporoni PC, do Rego MA. Influence of saliva contamination on the shear bond strength of orthodontic brackets bonded with self-etching adhesive systems. Am J Orthod Dentofacial Orthop. 2010 Jul;138(1):79-83.
26. Sfondrini MF, Fraticelli D, Gandini P, Scribante A. Shear bond strength of orthodontic brackets and disinclusion buttons: effect of water and saliva contamination. Biomed Res Int. 2013;2013:180137.
27. Shaik JA, Reddy RK, Bhagyalakshmi K, Shah MJ, Madhavi O, Ramesh SV. *In vitro* Evaluation of Shear Bond Strength of Orthodontic Brackets Bonded with Different Adhesives. Contemp Clin Dent. 2018 Apr-Jun;9(2):289-292.
28. Robaski AW, Pamato S, Tomás-de Oliveira M, Pereira JR. Effect of saliva contamination on cementation of orthodontic brackets using different adhesive systems. J Clin Exp Dent. 2017 Jul 1;9(7):e919-e924.
29. Güngör AY, Alkis H, Turkkahraman H. Effects of contamination by either blood or a hemostatic agent on the shear bond strength of orthodontic buttons. Korean J Orthod. 2013 Apr;43(2):96-100.
30. Hormati AA, Fuller JL, Denehy GE. Effects of contamination and mechanical disturbance on the quality of acid-etched enamel. J Am Dent Assoc. 1980 Jan;100(1):34-8.
31. Arici N, Bulut E. Shear bond strength of orthodontic attachments bonded to impacted teeth under in vivo and in vitro conditions. Orthod Craniofac Res. 2014 Aug;17(3):170-7.
32. 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.
33. Knaup I, Böddeker A, Tempel K, Weber E, Bartz JR, Rückbeil MV, Craveiro RB, Wagner Y, Wolf M. Analysing the potential of hydrophilic adhesive systems to optimise orthodontic bracket rebonding. Head Face Med. 2020 Sep 5;16(1):20.
34. 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 Oct;124(4):414-9.