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Evaluation of the Effects of the Universal Bond on the Shear Bond Strength of Orthodontic Brackets Bonded with 2 Types of Composites Containing Primers

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Abstract

Aim: The primer-containing composites, which eliminate the bonding step, decrease clinical time and securely attach the bracket to the tooth. Given the significant role of bonding in the bond strength of orthodontic adhesives, this study aims to investigate the effect of using a universal bond with two types of primer-containing composites on the bond strength of these composites.

Methods: Sixty healthy premolars were collected and divided into four equal groups: GC Ortho Connect composite, GC Ortho Connect composite with a universal bond, OrthoCem composite, and OrthoCem composite with a universal bond. The shear bond strength was measured using a universal testing machine, and the residual adhesive index was measured using a stereomicroscope at a 10x magnification.

Results: The shear bond strengths of the GC Ortho Connect group without a universal bond, the GC Ortho Connect group with a universal bond, the OrthoCem group with a universal bond, and the OrthoCem group without a universal bond were calculated to be 21.54, 12.88, 12.37, and 11.68 MPa, respectively. The analysis of variance (ANOVA) showed that the GC Ortho Connect group without a universal bond had a significantly higher shear bond strength than the other groups. The results also indicated that the universal bond reduced the shear bond strength in the GC Ortho Connect composite (p-value <0.001) and had no significant effect on the shear bond strength of the OrthoCem composite (p-value=1.000).

Conclusion: While the application of a universal bond considerably diminishes the shear bond strength in the GC Ortho Connect composite, it does not exert a significant influence on the OrthoCem composite. This suggests that the effectiveness of a universal bond may be dependent on the specific composite used, necessitating further investigations into optimizing bonding methods for different composite materials in orthodontics.

Keywords: Orthodontic bracket, Shear strength, Orthodontic adhesives, Resin composite, Cement

1. Background

Establishing a reliable bond between the bracket and the tooth is crucial during orthodontic treatment due to its long-term nature and associated challenges for both dentists and patients, including increased risk of caries, gingival recession, and root resorption. Also, preventing bracket debonding and the need for replacement is essential to avoid extended treatment time and material cost (1-3). o achieve proper bracket bonding, dental adhesive systems have undergone significant advancements since their introduction in the late 1950s (4-6). Initially, flow composites and restorative nanocomposites were used (7, 8), but their inability to withstand high stress at the teeth-bracket junction led to the development of orthodontic composites, such as Transbond XT. These composites offer higher filler content and modulus of elasticity, less polymerization stress, and greater bond strength to teeth (9). Recent advances have integrated adhesives and resin composites into orthodontic composites, saving time and eliminating the need for primers (10, 11). OrthoCem and GC Ortho Connect, for example, provide equal or greater bond strength than the usual three-step method, demonstrating good resistance against chewing forces and reduced bond failure due to high elasticity (3, 10, 12-14). GC Ortho Connect features high translucency, aesthetics, and resistance to staining. Its fluoride content reduces enamel demineralization and the formation of white spots, and its consistency facilitates clinical use. Furthermore, its fluorescent detector enables the removal of cement after bonding or debonding (13, 14).

However, there are some ongoing studies examining the use of universal bonding with primer-containing composites to enhance shear strength. Therefore, this study aims to investigate the impact of using or not using universal bonds on the shear bond strength (SBS) of orthodontic brackets.

2.Methods

This study was performed in vitro on 60 premolars extracted for orthodontic purposes with no caries, enamel cracks, or specific enamel defects on the buccal surface. The number of subjects were calculated based on the results of a previous study by Dadgar et al. (5) The first samples were disinfected, then the surfaces of the specimens were cleaned and polished by brushing using fluoride-free pumice paste for 10 seconds(15, 16). Next, the samples were randomly divided into four groups of 15.

Group A (GC Ortho Connect without universal bond):

In the first group, the buccal surface of the samples was etched with 37% phosphoric acid for 30 seconds using Den-fil (Vericom, Gyeonggi-do, South Korea). It was then washed for 30 seconds and air-dried for another 30 seconds. The prepared composite (GC Ortho Connect, GC Orthodontics, Breckerfeld, Germany) was placed on a metal bracket (Universal premolar 0.18 standard AO, Mini-master series, American Orthodontics, USA) with a cross-section of 2.49 × 3.70 mm^2. The bracket was positioned at the center of the buccal surface of the tooth with uniform pressure. Excess composites were removed using a composite probe, and then the assembly was cured using a light-cure device (LED.F, Woodpecker, China) with an output beam width of 420-480 nm for 10 seconds (five seconds from the mesial and five seconds from the distal according to the manufacturer’s instructions) in a tangential direction to the bracket (10).

Group B (GC Ortho Connect with Universal bond):

Initially, the buccal enamel of the samples was etched in a manner similar to that used for Group A. The universal bond (G-Premio BOND, GC, Tokyo, Japan) was then applied to the buccal surface of the tooth, evenly dried with an air spray for five seconds, and cured with light for 20 seconds. Finally, the composite and bracket were positioned on the tooth and cured.

Group C (OrthoCem with Universal Bond):

First, the buccal enamel of the samples was acid-etched (Condac 37, FGM, Stamford, USA) for 15 seconds according to the manufacturer's instructions. It was then washed for 30 seconds and air-dried for 30 seconds. The universal bond was then applied to the buccal surface of the specimens. Finally, the composite (OrthoCem, FGM, Stamford, USA) and the bracket were placed on the teeth and cured by the light cure machine for 20 seconds according to the manufacturer's instructions (14).

Group D (OrthoCem without Universal bond):

Samples were etched for 15 seconds according to the manufacturer's instructions. Then, the OrthoCem composite was placed on the bracket and teeth and cured for 20 seconds.

As shown in Fig. 1, samples from all four groups were mounted with instant acrylic until the tooth crown was protruding from the acrylic. The samples were immersed in distilled water at 37° C for 24 hours before the shear strength of the bond was checked (16). As shown in Fig. 2, the universal testing machine Z050 (Zwick / Roell, Germany) was used to measure the shear bond strength of the samples. Each specimen was secured in the machine and subjected to a 0.5 mm end shear force, applied parallel to the base bracket in the occlusal-lingual direction between the base bracket and the tooth at a speed of 1 mm per minute (3). The bond strength for each sample was then determined in MPa.

After the brackets were removed, the amount of adhesive remaining on the tooth surface was evaluated using the Adhesive Remnant Index (ARI), as shown in Fig. 3. The samples were examined under a SMZ800 stereomicroscope (Nikon, Japan) with 10x magnification. ARI scores were determined by a blind observer and were relative to the grouping of the samples. The ARI index is ranked as follows (11):

Zero rating: No adhesive is left on the tooth.

Rank one: Less than 50% of adhesive remains on the tooth.

Rank two: More than 50% of adhesive remains on the tooth.

Rank three: All adhesives remain on the teeth.

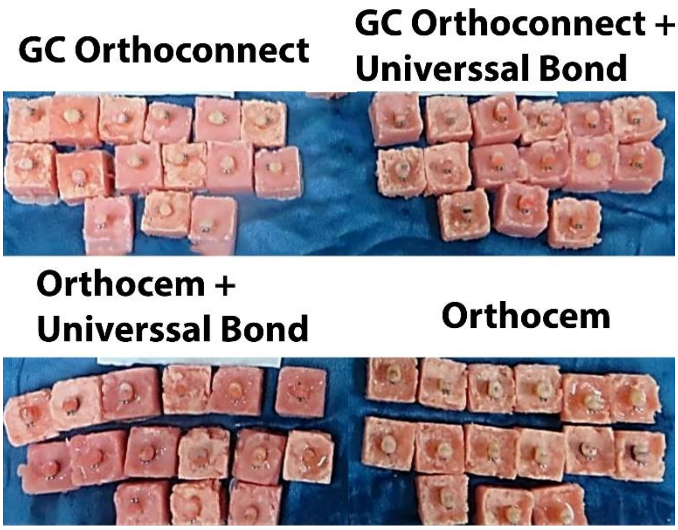

Figure 1. Mounted specimens with instant self-cure acrylic RE (Acropars, Iran). The crown of the tooth is immersed in acrylic up to the CEJ.

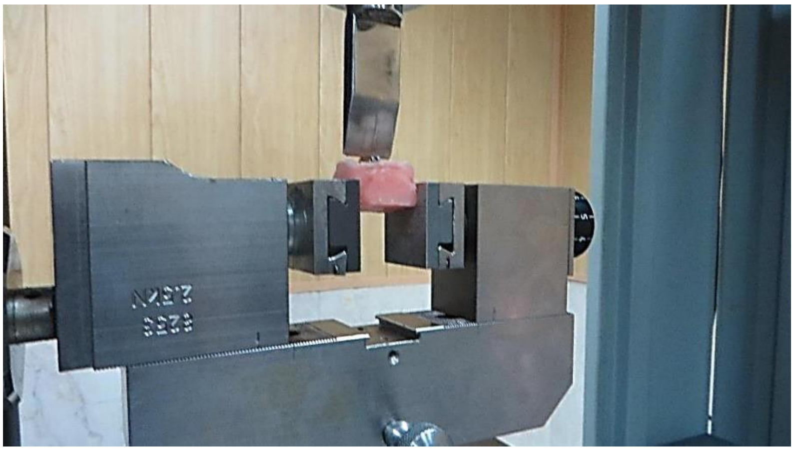

Figure 2. An image of a sample fixed on the UTM device.

Statistical analysis:

All statistical analyzes were performed by SPSS software (version 25, NY, USA). P-value<0.05 was considered statistically significant. SBS was evaluated by the ANOVA. Post hoc tests were used in this study to detect differences between means of the multiple groups while controlling for experimental error.

Figure 3. Stereomicroscope (SMZ800, Nikon, Japan)

3.Results

In this study, we investigated the Shear Bond Strength (SBS) of 60 specimens, which were divided into four different groups based on two different factors. As shown in Table 1, the SBS of the GC Orthodontics group without the universal bond ranged from 30.81 to 3.71, with an average of 21.54 (7.50 standard deviation), which was higher than that of the other groups. The average SBS in the other groups was found to be similar to each other.

Table 1. Shear bond strength (MPa) in the four studied groups

Group	Number	mean	standard deviation	minimum	maximum
GC Orthodontics without universal bond	15	21.54	7.50	3.71	30.81
GC Orthodontics with universal bond	15	12.88	3.30	9.96	22.87
Orthocem without universal bond	15	11.68	4.14	3.40	17.85
Orthocem with universal bond	15	12.37	4.36	5.45	20.84
Total	60	14.62	6.40	3.40	30.81

To compare the SBS values among the four groups, a two-factor ANOVA test (composite resin type and the condition of the universal bond used) with interaction effect was conducted. As the differences among the groups were significant based on the obtained results, a post hoc Tukey test was employed.

According to the two-factor ANOVA results, the effects of the resin type (P <0.001), bond use (P=0.004), and their interaction (P=0.001) were statistically significant.

The Tukey test was used for post hoc comparisons to identify differences among the multiple groups. According to the Tukey test results (Fig. 4), the SBS in the GC Orthodontics group without a universal bond differed significantly from the other groups (p-value<0.05). In contrast, pairwise comparisons of the other groups revealed no significant statistical difference among them (p-value>0.05).

Table 2 reports the amount of adhesive remaining on the teeth in each of the four groups studied. According to the Kruskal-Wallis test, the distribution of residual adhesive was not the same across the study groups (p-value <0.001). For example, in the GC Orthodontics group without a universal bond, about 50% of the samples retained 100% of the adhesive, whereas none of the other three groups exhibited this rate.

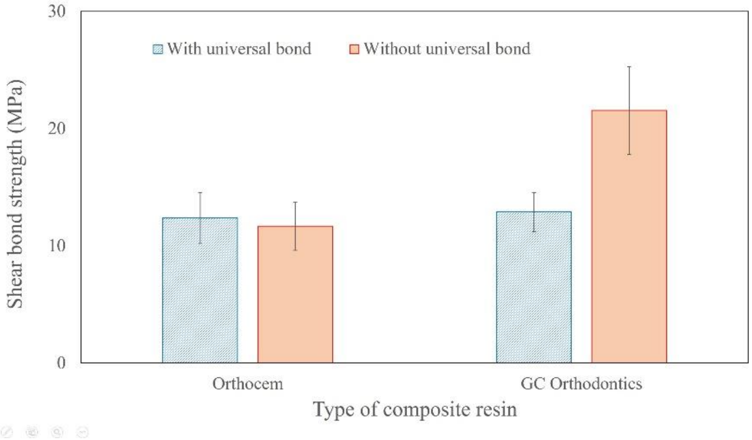

Figure 4. Shear bond strength by resin and bond type. Vertical lines, 95% confidence interval of shear bond strength, and star indicate different groups in this regard.

Table 2. The amount of residual adhesive (ARI) on the teeth in each of the studied groups

Group	Adhesive Remnant Index (ARI)				Total	P-value
	0	1	2	3		
GC Orthodontics without universal bond	15	21.54	7.50	3.71	30.81	<0.001
GC Orthodontics with universal bond	15	12.88	3.30	9.96	22.87	
Orthocem without universal bond	15	11.68	4.14	3.40	17.85	
Orthocem with universal bond	15	12.37	4.36	5.45	20.84	
Total	60	14.62	6.40	3.40		30.81

4. Discussion

Bond strength is a determinant in different adhesive system studies (17, 18). Since different forces are applied to the brackets in the mouth, the strength of these bonds can be tested in the laboratory (19-21). In our laboratory study, the SBS obtained for GC Ortho Connect was 12.88 MPa with universal bond and 21.54 MPa without it, and for OrthoCem with and without universal bond, 12.37 and 11.68 MPa, respectively. In the study by Ok et al. a similar SBS was obtained for the GC Ortho Connect composite(22). However, in the study of Bilen et al., the SBS of GC Ortho Connect was measured at 18.16 MPa. The reason for the differences in these two studies compared to the present study could be related to not using thermocycling and also less etching time (15 seconds vs. 30 seconds) (10). Matos et al., by examining the effect of various factors on bond strength in orthodontics, concluded that the use of acid etch is one of the factors affecting shear bond strength(20). In a study by Elkalza et al., they showed that the force to bond the bracket to the tooth surface is 191.3 N. In the present study, the number obtained is 223.3(3). In the mentioned study, thermocycling was not applied, similar to the present study, but the reason for the higher force obtained in the present study may be due to the lack of enamel etching in the Elkalza study. Various studies have found that thermocycling did not make a significant difference in shear bond strength (23, 24). In addition, studies have shown that using universal bonding to attach brackets to uncut enamel does not provide clinically optimal shear bond strength (15, 25). The results of the study by Cerone et al. showed that the SBS in the three various universal bonds is between 1.9 and 4.1 MPa, none of which is in the range of 6 to 8 MPa (15).

In two studies, Samadi et al. in 2019 and Geraldi et al.in 2021 obtained higher bond shear strength for OrthoCem composite without the use of a universal bond than in the present study (16.20 and 15.17 vs. 11.68 MPa, respectively) (13, 14). The reason for this increase in bond strength obtained may be related to the smaller cross-sectional area of the bracket used in the two studies. In the study of Lon et al., the shear strength of the OrthoCem composite bond showed 18.08 MPa, which can be attributed to the time of 30 seconds of enamel etching (15 seconds more than the present study) as well as the smaller cross-section of the brackets (26). Dos Santos et al. found that the use of universal bonding significantly increases the shear strength of the bond in OrthoCem composite(27).

Similar to this study, Fonseca-Silva et al. in their study concluded that the use or non-use-of-bond units with composite OrthoCem in SBS of the composite did not indicate any difference (28).

Results in ARI are also very similar. In the GC Ortho Connect composite without a universal bond group, which showed the highest SBS in about 50% of the samples, we observed a grade 3 adhesive remnant index, and all adhesives remained on the samples after debonding. Grade 3 was not observed in any of the other groups, and only grades zero and one were recorded on the adhesive remnant index. In a study by Bilen et al., in 50% of specimens bonded with GC Ortho Connect and all adhesives remained on the tooth (grade 3 ARI index) (10) In the study of Ok et al., out of 18 specimens bonded by GC Ortho Connect, in eight specimens, after removing the brackets, 100% of adhesive remained on the tooth (22). In the study of Shapinko et al., it was found that in half of the bonded specimens by GC Ortho Connect, more than 50% of the adhesive remained on the teeth(29). The bond strength obtained for GC Ortho Connect composite in their study is 6.57 MPa, which can be a reason for the low ARI index in their study compared to the present study. In the study of Dadgar et al., in only 2% of GC Ortho Connect samples, all adhesives remained on the teeth after debonding, and in more than half of the samples, less than 10% of adhesives were observed on the teeth (5).

In the study of Samadi et al., it was observed that in 40% of the samples bonded with OrthoCem composite, no adhesive was left on the tooth (zero degree of ARI index) and in 60% of them, less than 10% of adhesive remained on the tooth (grade 1 ofindex ARI) (13). In a study by Lon et al., to examine the OrthoCem composite, 14 zero-grade and one-grade samples and one grade 2 sample was recorded based on the ARI index (26). The reason for the slight increase in residual adhesive in this study could be attributed to longer etching time and higher SBS. In addition to all the points mentioned and the differences in the methods and materials used, the storage and transfer conditions of the samples and the differences in them can affect the SBS. Klocke and Kahl-Nieke (2005) found that holding and manipulation conditions of extracted teeth before and during testing could affect their surface adhesion energy. Hence, these changes, along with the effects of dehydration and repeated rehydration, can influence laboratory testing results, leading to variations in it outcomes (30).

Conclusion

The results showed that the use of a universal bond with GC Ortho Connect significantly reduces the SBS of this composite, and the use of a universal bond with OrthoCem composite causes some increase in the SBS although this increase is not statistically significant.

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