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Comparison of the Initial Repeated Bond Strength among Three Orthodontic Bonding Systems

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Abstract. One of the problems that often occurred during orthodontic treatment is bracket failure. This is usually the result either of the patient's accidentally, applying inappropriate forces to the bracket or of a poor bonding technique. Thus, a significant number of teeth have to be rebonded in an orthodontic practice. The aim of this study was to evaluate the in vitro initial repeated shear bond strength of the three adhesive systems at two and five minutes after placement of a bracket.

The three bonding agent adhesives are System1+, Rely-a-bond, Unite. Two hundred and forty human premolar teeth were divided into two groups, a control and an experimental group. Each group was further divided into three subgroups for bonding brackets with the three different adhesives. Only the teeth in the experimental group were sequentially bonded and debonded two times with the same adhesive. The teeth in control and experimental groups were tested for shear bond strength (at two and five minutes after the bracket was bonded) with an Instron testing machine.

The studies were found that : (1) there were differences between the shear bond strength of each adhesive in the control and experimental group. Unite had the highest shear bond strength followed by Rely-a-bond and System1+ at two minutes and five minutes, (2) the experiment group (rebonded brackets) had higher shear bond strength than control group and Unite had in significant difference($p<0.05$) of initial repeated bond strength with System1+ and Rely-a-bond at two minutes and five minutes and (3)there were mostly significant difference($p<0.05$) between repeated shear bond strength at two minutes and repeated shear bond strength at five minutes**.**

There were significant difference of the initial repeated shear bond strength of each adhesive. The orthodontists should be aware of applying force for tooth movement into the repeated bonding brackets.

Introduction

Composite resins have been widely used for the attachment of orthodontic brackets [1-3, 13] because of their high bond strength. Nowadays, chemical cured bonding adhesives are adhesives available for clinical use, which have the difference in their composition, mixing technique, advantages, disadvantages etc. [7, 8]. They are currently the most popular use for bonding metal brackets because of easier to apply and remove. Even though tremendous advances in the development of orthodontic adhesives have allowed orthodontists to bond brackets or attachments to tooth surfaces quite successfully, studies have shown that clinical bond failure still occurs with 5% to 7% of brackets bonded with composite resins for different reasons [22, 23]. Moreover, during orthodontic treatment the clinician may decide to debond one bracket (or more) intentionally, and repeated bond a bracket on the tooth in a better position. Therefore, repeated bonding a bracket is a common procedure in orthodontic treatment. Sometimes, in a busy situation, the orthodontists may have not enough time to leave a repeated bond bracket long as companies' recommendation. The purpose of this study is to determine and compare the initial bond strength and the initial repeated

bond strength of stainless steel mesh-backed orthodontic brackets to enamel surfaces in vitro among three no-mix adhesive bonding resins at 2 and 5 minutes after repeated bonding.

Materials & Method

Two hundred and forty human premolar teeth extracted for orthodontic purposes were used in this experimental study. All teeth were free from carious lesion, restoration, enamel crack, enamel hypoplasia or abnormal buccal surface anatomy that might affect the strength of the enamel. The age and sex of the patients were not considered. The teeth were stored in distilled water to prevent dehydration and bacterial growth. Before testing, all teeth were visually inspected for fractures by observing under a 4 x 10 microscope. If any enamel fracture was found, the tooth would be excluded. All brackets used in this experiment were 0.022" x 0.028" slot upper and lower premolar standard edgewise stainless steel brackets. (Minidiamond, Ormesh®,Ormco Corporation, CA.USA.)

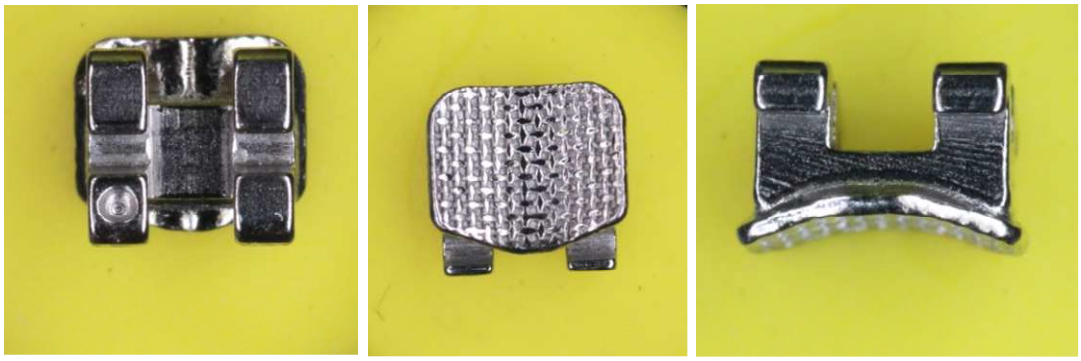

Fig. 1 The bracket used in this experiment.

The three bonding no-mix adhesives used in this study were (1) System 1+ (Ormco corporation, Glendora, CA, USA) lot No. 01D8 (2) Rely-a-bond (Reliance orthodontics product Inc., Itasca IL,USA) lot No.149173 (3) Unite (Unitek, 3M dental product, CA ,USA) lot No.010531.

Tooth specimens: Two third of the root of each sample tooth were cut off and then the lingual surface was grooved with a carborundum disc to aid retention. Each tooth was mounted in a mounting ring with self-cured acrylic resin (Formatray®, KERR Manufacturer company, USA) to facilitate testing. The mounting ring was made from a PVC tube, which had 17 mm in diameter, 12.5 mm in height, and 2 mm in thick. The buccal surface of each tooth was kept parallel to the upper surface of the mounting ring, by fixing the tooth in the desired position with sticky wax on horizontal plane until the acrylic resin was set. The specimens were kept in the distilled water until the scheduled testing time.

Fig. 2 Tooth was embedded in PVC block.

Two hundred and forty teeth specimens attached with bracket at the buccal surface by each bonding adhesive were divided into 2 groups for control and experimental group; each group consisted of 120 specimens. Each group was divided into 3 subgroups for three bonding adhesives

(40 specimens) and in each subgroup was divided into 2 groups (n = 20) for testing the initial shear and repeated shear bond strength at 2 and 5 minutes.

Control group

Group 1(n=20) : bonded with System1+ and tested at 2 minutes (SC2).
Group 2(n=20) : bonded with System1+ and tested at 5 minutes (SC5).
Group 3(n=20) : bonded with Rely-a-bond and tested at 2 minutes (RC2).
Group 4(n=20) : bonded with Rely-a-bond and tested at 5 minutes (RC5).
Group 5(n=20) : bonded with Unite and tested at 2 minutes (UC2).
Group 6(n=20) : bonded with Unite and tested at 5 minutes (UC5).

Experimental group

Group 1(n=20) : repeated bond with System1+ and tested at 2 minutes (SR2)
Group 2(n=20) : repeated bond with System1+ and tested at 5 minutes (SR5)
Group 3(n=20) : repeated bond with Rely-a-bond and tested at 2 minutes (RR2).
Group 4(n=20) : repeated bond with Rely-a-bond and tested at 5 minutes (RR5).
Group 5(n=20) : repeated bond with Unite and tested at 2 minutes (UR2).
Group 6(n=20) : repeated bond with Unite and tested at 5 minutes (UR5).

The shear bond strength testing was done in a universal testing machine (Instron model 4502, serial No.H.3342, High Wycome, UK.) Each mounting ring with the specimen was mounted in the lower part of the alignment block, which was fixed to the base of the tester. The upper part of the testing machine was a ram with a knife-edge tip. Then the testing procedure begins by brought down the tip of the upper part at the bracket-resin interface and apply load until the bracket was dislodged. The Instron was set at a cross head speed of 0.5 mm per minute and loading cell was 10 kN, the shear force generated was measured in Megapascals (MPa) and recorded at the point at which bond failure occurred.

Statistical Analysis

Mean values and standard deviations of the shear bond strengths were computed. The data of shear bond strength were tested for normality with the Kolmogorov-Smirnov method. Differences between the groups were then evaluated by One-way ANOVA and a Scheffe's multiple comparison test. The overall test was interpreted for significance at p-value less than 0.05.

Results

The mean shear bond strength and standard deviation of the control and experimental groups at 2 minutes and 5 minutes after bonding are shown in Table 1. Unite had the highest mean shear bond strength followed by Rely-a-bond and System1+ in control group and experimental group. From Table II indicates that there were significant differences (p0.05) between mean shear bond strength of Unite - System1+ and Unite - Rely-a-bond at 2 mins. and 5 mins after initial repeated bonding procedure, however, System1+ and Rely-a-bond did not show significant differences in shear bond strength on both time after initial repeated bonding adhesive. For the shear bond strength between the control and experiment group of each adhesive in Table III, there were in significant difference ($p<0.05$) between SC2-SR5, SR2-SR5 and SC5-SR5 for System1+ adhesive; RC2-RC5, RC2-RR5, RR2- RC5, and RR2- RR5 for Rely-a-bond adhesive; and UC2- UC5 and UC2- UR5 for Unite adhesive.

Table 1 Descriptive statistics of shear bond strength (MPa) of the experimental and control groups.

Group*	N	Mean	SD	Range
SC2	20	1.1	0.9	0.1-3.1
SC5	20	2.1	1.4	0.06-5.0
RC2	20	3.2	1.7	0.8-7.6
RC5	20	6.3	3.7	1.3-15.0
UC2	20	5.3	1.8	2.7-8.8
UC5	20	10.6	6.2	2.0-22.6
SR2	20	1.3	0.6	0.7-3.0
SR5	20	3.6	2.1	1.2-10.6
RR2	20	2.6	1.3	0.4-5.8
RR5	20	5.6	1.3	3.4-8.9
UR2	20	9.1	5.3	3.7-26.4
UR5	20	12.3	4.6	5.9-24.1

Table 2 Results of analysis of variance comparing mean shear bond strength (MPa) between bonding type

Adhesives	SR2	RR2	UR2	Adhesives	SR5	RR5	UR5
SR2	-	-	*	SR5	-	-	*
RR2	-	-	*	RR5	-	-	*

*Significant difference at p< 0.5

Table 3 Results of analysis of variance comparing mean shear bond strength (MPa) between experimental and control groups.

System1	SC2	SR2	SC5	SR5	RelybondI	RC2	RR2	RC5	RR5	Unite	UC2	UR2	UC5	UR5
SC2	-	-	-	*	RC2	-	-	*	*	UC2	-	-	*	*
SR2	-	-	-	*	RR2	-	-	*	*	UR2	-	-	-	-
SC5	-	-	-	*	RC5	-	-	-	-	UC5	-	-	-	-

*Significant difference at p< 0.5

Discussion

According to the results from Table I, it is indicated that Unite had the highest bond strength when compared with System1+ and Rely-a-bond both in control and in repeated bond groups. The reason may be due to the faster polymerization process of Unite when compared with System1+ and Rely-a-bond. However, information on the type and amount of initiator and activator is not available. Another reason may be the higher amount of fillers in Unite than others. If amount of fillers increases, the bond strength will be increased (34). Unite has comparable amounts of filler approximately 66% by weight and System1+ has only 41% filler by weight (34). However, Rely-a-bond has no data available.

There are many factors that responsible for the consistency of resins (34), such as the amount, size and shape of the added filler, the amount and type of diluents and other ingredients that manufacturer may add. Information on the amount and type of diluents in all the resins is not available. System1+ contains a urethane oligomer, which has a chemical affinity for the monomeric units, increasing their molecular weight. This oligomer was claimed to improve the bond strength of System1+ with the lowest amount of filler by weight of all the resins tested. Although System1+ does contain that oligomer but the findings from the present study still showed that System1+ produced the lowest initial shear bond strength. Thus, it may be implied that the effect of filler may have a greater influence on the initial shear bond strength than the effect of oligomer. Furthermore, the type of filler in Unite and in System 1+ may be different, so their bond strengths exhibited the different results. Table II demonstrated the repeated shear bond strength of each bonding agents.

Unite had the significantly highest shear bond strength followed by Rely-a-bond and System1+, both in repeated bonding time. The most appropriate repeated bonding resin (at 2 and 5 minute) among these resins was Unite. The shear bond strength of Unite was 9.1 MPa at 2 minutes and 12.3

MPa at 5 minutes after repeated bond. These two time shear bond strengths after repeated bond were higher than Reynold' study (13) who reported successful clinical bonding should be in the range of 6-8 MPa. Greenlaw et al. (37) also reported the minimal debond loads required for a successful orthodontic adhesive should be in the range of 8-20 lbs or 3.5 to 8.9 MPa. Furthermore, when compared the shear bond strength of Unite with Concise in the study of Chamda and Stein (22), they founded that at 2 minutes after bond with Concise the shear bond strength was only 0.93 MPa and 4.11 MPa at 5 minutes. The reason may be due to the catalyst or initiator system of Unite was more efficient than that of other resins in this study, so Unite could polymerize almost completely in short time. The data from the present study implies that the orthodontists can place the archwire almost immediately (within 2 minutes) after repeated bond a bracket with Unite.

Rely-a-bond had the second strong bond strength among these three resins. It produced the fair repeated bond strength, 2.6 MPa at 2 minutes and 5.6 MPa at 5 minutes after repeated bond). Steckel et al. (35) reported the shear bond strength of Rely-a-bond for 1 day was 7.8$\pm$3.8 MPa and 17.1$\pm$4.4 MPa for 30 days. Other studies (38, 39) reported the range of 6.8-7.8 MPa repeated bonded strength after 1 week, these data all showed that Rely-a-bond could achieve the optimum shear bond strength if it was left unloaded for longer periods of time.

System1+ had the low bond strength (1.3-3.6 MPa) both time after repeated bond. The result in this study showed that System1+ was the lowest rank to be chosen for repeated bonding a bracket. However, the study of Chamnankit (24), reported the shear bond strength of System1+ at 15 minutes was 5.5 MPa and 13.6 MPa at 24 hrs. The findings from this study suggested that more flexible archwire should be tied on the rebonded bracket when System1+ is used instead of Rely-a-bond or Unite.

Results in Table III demonstrated that the shear bond strengths in the control group and the experiment group were increased with time for all adhesive types. When ANOVA was used, the repeated bond strengths after 5 minutes showed significantly higher ($p<0.05$) than those after 2 minutes in both System1+ and Rely-a-bond. This indicated that more than 5 minutes should be preferable to repeated bond a bracket with System1+ or Rely-a-bond. In contrast, there was no significant difference between the repeated bond strength after 2 minutes and after 5 minutes in Unite group. The finding suggested that repeated bonding a bracket with Unite would produce acceptable bond strength within 2 minutes. In other words, Unite reached its clinically accepted bond strength faster than System1+ or Rely-a-bond.

In the present study, the initial repeated bond strengths of System1+ and Unite in experiment group were higher than in control group, whereas it was lower in Rely-a-bond. The difference between the results of the present study and those of Bishara et al.[15] may be attributed to the reconditioning method. An adhesive removing pliers was used in this study which differences in reconditioning methods may produce differences in the amount of adhesive remnants and enamel surface roughness which in turn affecting the bond strength.

Conclusion

This study was designed to compare the initial repeated shear bond strength among three bonding agent adhesives. Unite had the highest shear bond strength followed by Rely-a-bond and System1+ respectively, both in 2 minutes and 5 minutes after repeated bond groups. The System1+ and Unite had the initial repeated bond strengths higher than initial bond strengths at 2 minutes and 5 minutes in control group. Only the repeated bond strength of Rely-a-bond was non significantly lower than initial bond strength at 2 and 5 minutes in control group. The repeated shear bond strength at 5 minutes of System1+ and Rely-a-bond was significantly higher than the repeated shear bond strength at 2 minutes except Unite was non-significant difference.

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