

## Failure Site and ARI Score of Rebonded Brackets Using No-Mix Adhesive Resins

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**Abstract.** To evaluate failure sites and ARI scores of re-bonded brackets after debonding of three no-mix adhesive brands. 120 teeth were divided into 2 groups for bonded and rebonded (60 teeth/group) and 3 subgroups (20 teeth/subgroup) for three no-mix adhesive, System1+, Rely-a-bond, and Unite. Tooth surface and bracket base were inspected by low power light microscope (10X) after debonding. The failure sites were assessed and residual adhesives was recorded using the Adhesive Remnant Index (ARI). The failure sites were expressed in percentage and Chi-square was used to determine significant differences in the ARI scores among groups ( $p < 0.05$ ). After rebonding brackets, the failure site of no mix adhesive in bonding were changed to cohesive layer in rebonding group except Unite adhesive. ARI scores of all adhesive were changed from score 2 in bonding group to score 3 in rebonding group after debonding bracket. There were significant ( $p < 0.05$ ) differences in the ARI scores between bonded and rebonded groups except Unite and System1+ and between Unite groups. The results showed that the failure site mostly changed to cohesive layer and ARI changed to Score 3 in three no-mix adhesives after debonding in rebonding brackets.

### Introduction

The development of orthodontic adhesives has allowed orthodontists to bond brackets or attachments to tooth surfaces quite successfully. However, many studies have shown that clinical bond failure still occurs in 5-7% of brackets bonded with composite resins for various reasons [1, 2]. Moreover, during orthodontic treatment the clinician may decide to intentionally debond one or more brackets, and rebond them on the tooth in a better position. Repeated bonding of a bracket is a common procedure in orthodontic treatment. Most published data have focused on the failure sites and adhesive remnants on firstly bonded brackets. Only a few studies have addressed these problems on rebonded brackets [3]. A repeated bond tooth had higher shear bond strength than initially bond. Therefore, the aim of the present study was to investigate the failure sites and adhesive remnant index (ARI) scores in tooth surfaces of bonded and rebonded brackets after debonding brackets using three commercially available no-mix adhesive resins.

### Materials and Methods

One hundred and twenty human premolar teeth extracted for orthodontic treatment were used in this study. The teeth were free from carious lesion, restoration, enamel crack, enamel hypoplasia, or abnormal buccal surface anatomy. The brackets used in this study were 0.022" × 0.028" slot premolar standard edgewise stainless steel brackets (Minidiamond, Ormco Corporation, USA).

The three no-mix adhesive resins used in this study were System 1+, 5 min for setting time (Ormco Corporation, USA), Rely-a-bond, 5 min for setting time (Reliance Orthodontics Product Inc., USA), and Unite, 4 min for setting time (Unitek, USA). Each tooth was mounted in a

mounting ring with self-cured acrylic resin to facilitate testing. The buccal surface of each tooth was kept parallel to the upper surface of the mounting ring. One hundred and twenty teeth were divided into 2 groups, namely bonded and rebonded groups, with 60 teeth/group. Each group was divided into 3 subgroups depending on the brand of no-mix adhesive resin used, with 20 teeth/subgroup.

Bonded group; Group 1(n=20): bonded with System1+, Group 2(n=20): bonded with Rely-a-bond, Group 3(n=20): bonded with Unite.

The bracket was bonded on the teeth by 3 different adhesive resins (System1+, Rely-a-bond, and Unite). The bonding approach followed the manufacturers' instructions. The bonding of all brackets was performed by a single operator to standardize the technique as in a clinical situation. The type of bracket was matched with the type of tooth. After bonding of the brackets, all teeth were stored in distilled water at 37°C in an incubator for 24 hrs, and the teeth were thermocycled between 4°-56°C for a total of 1500 cycles and stored again in distilled water at 37°C for 24 hrs in an incubator to ensure that the bonding process had completely set and stored in the temperature as in oral cavity.

Rebonded group;

Group 1(n=20): repeated bond with System1+ and debonded at 5 minutes after bonding

Group 2(n=20): repeated bond with Rely-a-bond and debonded at 5 minutes after bonding

Group 3(n=20): repeated bond with Unite and debonded at 5 minutes after bonding

In the bonding group, the brackets were debonded with Instron testing machine and the failure site and ARI scores were recorded. The residual material was removed by an adhesive removing plier and polished with pumice. The bonding procedures were repeated again on the same tooth surface with the same approach detailed earlier. After 5 minutes, the bracket was debonded with a crosshead of an Instron testing machine. Following which, the failure site and ARI scores were recorded.

Residual adhesive: After bracket dislodged, failure site and the adhesive remnants on the tooth surface was evaluated. Each tooth and the bracket base were visually inspected under low power magnification (10X) using a light microscope. The failure sites were divided into 3 locations: EA= enamel/adhesive interface (0-25% of the adhesive left on the tooth); CO= cohesive failure, within the adhesive (25-75% of the adhesive left on the tooth), and BA= bracket/adhesive interface (75-100% of the adhesive left on the tooth). The amount of residual adhesive remaining attached to the enamel were assessed by using modified Adhesive Remnant Index (ARI) scoring system as described by Artun and Bergland [4]. ARI scores ranged from 1-5: Score 1 (all adhesive left on the tooth), Score 2 (more than 90% of the adhesive left on the tooth), Score 3 (between 10-90% of the adhesive left on the tooth), Score 4 (less than 10% of the adhesive left on tooth), and Score 5 (no adhesive remains on tooth surface). Statistical analysis: The failure sites and ARI scores were expressed in percentage. Chi-square ( $\chi^2$ ) test was used to compare differences in the failure site of three no-mix adhesive resins by the Adhesive Remnant Index scores (ARI). The overall test was interpreted for significance at p-value less than 0.05.

## Results

The distribution of failure sites in the bonded and rebonded groups were mostly in the cohesive layer, except System1+ of rebonded group that had failure at the bracket adhesive layer (Table 1). The ARI score was Score 2 except Unite in bonding group and Score 3 in the rebonded group. The results of the Chi-square test in bonded and rebonded groups presented significance difference among the groups, as shown in Table 2 for bonded group (p=0.006) and rebonded group (p=0.026). In Table 3, there were significant differences between System1+ and Rely-a-bond (p=0.046) and Rely-a-bond and Unite (p=0.002) in bonding group. For the rebonded group, there were only significant differences between Rely-a-bond and Unite (p=0.029). Comparison of the bonded and rebonded groups (Table 4), revealed that there were no significant differences only between System1+ and Unite and between Unite in both groups.

Table 1. Distribution of failure site in bonded and rebonded group

Adhesives	Failure site in bonding group			Failure site in rebonding group		
	Enamel Adhesive	Enamel Adhesive	Cohesive	Bracket Adhesive	Cohesive	Bracket Adhesive
System1+	-	-	18(90%)	12(10%)	8 (40%)	12 (60%)
Rely-a-bond	-	-	20(100%)	-	20 (100%)	-
Unite	1 (5%)	6(30%)	9(45%)	5(25%)	12 (60%)	7 (35%)

Table 2. Distribution of ARI score in bonding and rebonded group

Adhesives	ARI score in bonding group					Sig.	ARI score in rebonding group					Sig.
	1	2	3	4	5		1	2	3	4	5	
System1+	-	10 (50%)	10 (50%)	-	-	P=0.006	-	2 (10%)	18 (90%)	-	-	P=0.026
Rely-a-bond	1 (5%)	16 (80%)	3 (15%)	-	-		-	-	20 (100%)	-	-	
Unite	-	5 (25%)	13 (65%)	2 (10%)	-		-	2 (10%)	14 (70%)	4 (20%)	-	

Table 3. Significant difference of ARI score in bonding and rebonding group

Adhesives	Bonding group			Rebonding group		
	System1+	Rely-a-bond	Unite	System1+	Rely-a-bond	Unite
System1+	-	P=0.046*	-	-	P = 147	-
Rely-a-bond	-	-	P=0.002*	-	-	P = 0.029*
Unite	P = 0.131	-	-	P = 0.105	-	-

\* Significance at  $p < 0.05$

Table 4. Significant difference of ARI score among three no-mix adhesive resin in bonded and rebonded group

Bonded Group	Rebonded Group			Sig.
	System1+	Rely-a-bond	Unite	
System1+	P = 0.006*	P = 0.0001*	P = 0.007*	P=0.0001
Rely- a bond	P = 0.0001*	P = 0.0001*	P = 0.0001*	
Unite	P = 0.129	P = 0.014*	P = 0.370	

\* Significance at  $p < 0.05$

## Discussion

For no-mix orthodontic adhesive bonding systems, most companies recommend that the adhesive should be allowed to set for 4-5 minutes before inserting archwires. This study employed 5 minutes setting time as recommended by the manufactures. This method may result in side effects, such as excessive enamel loss by inevitable over-range etching [5] and acid-etching induced vulnerable alterations in the enamel surface [6, 7]. Many investigators have reported variable sites of bond failure [8, 9]. It can be observed at enamel-adhesive interface or at bracket-adhesive interface or within the adhesive, depending on type of adhesive used. The importance concern is to avoid cohesive failures in the enamel during debonding of the brackets and at the same time to obtain tooth surfaces without adhesive. In debonding, the bond between the attachment and the tooth may be broken by adhesive or cohesive fracture of the resin and/or enamel or both [10]. Cohesive failure is safer than bracket adhesive failure because of less adherent adhesives on the enamel which requires less time to be removed. The result of the present study (Table 1) showed that the site of failure in the bonded and rebonded groups were mainly cohesive in nature, which was similar to previous observations [11-13]. Cohesive failure is preferred than enamel failure because of fewer remnant adhesives on the enamel surface and less damage to the enamel during removal of residual

adhesives. These are consistent with the studies by Klockowski *et al* [8] and Montasser *et al* [13], who observed that the most frequent failure site of Rely-a-bond was cohesive in nature.

For the etching process, phosphoric acid used during rebonding had no effect on residual resin patches and tags [14] but only cleaned the surface. Potential factors were evaluated by Sheykholeslam and Brandt [15] and Perry [14] in their SEM studies. According to the results of a study on rebonding, the conditioning solution may flow underneath the resin patches and promptly dissolve the enamel prisms that support the bonding agent. This undermines the resin that creating a mushroom effect. Due to this effect, numerous resin extension tags are exposed after the acid dissolves their enamel support, giving rise to a mushroom-like appearance. This effect may be responsible for retention in the rebonding process because the resin can extend under the mushroom-shaped resin tags, which can increase the bond strength [16]. These factors are depended on the consistency of the adhesive resins, which are able to flow into underneath the resin patches forming the interlocking with the enamel to increase the strength of resins; however, this study did not concern the consistency of adhesive resins. Table 3 showed that there were significant differences in ARI scores in bonded and rebonded groups of some adhesives. These might be due to differences in composition and consistency of the no-mix adhesive resins. However, considering the ARI scores between bonded and rebonded groups, there were significant differences in the scores between the adhesives, except System+1 –Unite and Unite in both groups. Montasser *et al* [16] reported ARI scores were not significantly different after the second or third debonding for Rely-a-bond adhesive, which was in contrast to the results of this study. In this study, the failure sites of no-mix adhesive resins in both groups were mostly cohesive failure. The ARI score for bonded group were Score 2 and 3, which indicated more remnant adhesives at the enamel surface than rebonded group, Score 3.

## Conclusion

The three no-mix adhesive resins in this study mostly showed cohesive failure after debonding in the bonded and rebonded groups. There were significant differences in the ARI scores of each no-mix adhesive in the bonded and rebonded groups, except Unite adhesive. All no-mix adhesives tested in this study showed less remnant adhesive at the enamel surface after debonding in the rebonded group.

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