Enamel surface damage after Use of self-etched Flowable composite and conventional orthodontic bonding systems "An in vitro study"

Rawof R. Al-Tuma, B.D.S., M.Sc.
University of Karbala/ college of dentistry/Iraq

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ABSTRACT:

Background: This study aims to evaluate enamel surface damage and the site of bond failure after using of two materials with each has different adhesive techniques. One of them is self-etch (7th generation bonding system) while the other with three steps conventional technique(5th generation bonding system).

Materials and methods: eighty premolars, extracted for orthodontic purposes, were divided into 4 groups of 20. The enamel surfaces were examined with 10X magnifying lens. Two types of bracket (stainless steel and ceramic) was bonded and debonded in each group using ligature wire cutter. The three steps adhesives was conventional orthodontic bracket adhesive of Oromco company, the self-etch flowable adhesive was Vertise flow flowable composite of Kerr company ;After debonding, the enamel surfaces were inspected under a stereomicroscope to determine the predominant site of bond failure and adhesive remnant index. *Then* stereomicroscope was used to evaluate enamel surface damage after the removal of residual adhesive.

Results: The reduction in enamel surface damage showed a statistically non-significant with the use of self-etched flowable adhesive in both ceramic and stainless steel brackets groups. The amount of the adhesive remained on the tooth surface significantly increase for groups that bonded with self-etched flowable adhesive in both stainless steel and ceramic brackets. The predominant failure site in self-etch flowable adhesive was between enamel and bracket for both types of brackets.

Conclusion: The enamel surface damage that results from debonding of conventional orthodontic adhesives was non significantly higher than that found with self-etch flowable adhesive for both metal and ceramic brackets "used in this study"

ضرر سطح المينا بعد استعمال الرابط المائع ذاتي اللصق وأنظمة الربط لتقويم الأسنان التقليدية "دراسة في المختبر"

المدرس المساعد:رؤوف رشيد جواد ال طعمة
بكالوريوس طب وجراحة الفم والاسنان- ماجستير تقويم اسنان . كلية طب الاسنان- جامعة كربلاء/العراق

الكلمات الرئيسية: تلف سطح المينا. مؤشر بقايا اللصق. اللصق الذاتي؛ المواد اللاصقة المائعة

ملخص :تهدف هذه الدراسة إلى تقييم أضرار المينا السطحية وموقع من فشل السندات بعد استخدام اثنين من المواد مع بعضها لديها تقنيات لاصقة مختلفة .واحد منهم هو اللصق الذاتي نظام الربط جيل في حين أ الآر مع ثلاث طوات (تقنية التقليدية)
ثمانو سن ضاحك مقلوعة لأغراض تقويم الأسنا، تم تقسيمهم إلى 4مجموعات . تم فحص السطوح المينا مع 10Xعدسة مكبرة . مع استخدام نوعين من سنادات التقويم (الفولاذ المقاوم للصدأ والسيراميك) . اللواصق المستخدمة كانت اللاصق التقليدي لتقويم من شركة Ormco، والاصق الذاتي المائع لشركة Kerr؛ بعد رفع الروابط، تم تفتيش السطوح المينا باستخدام المجهر لتحديد موقع فشل السندات والبقايا اللاصقة ثم تقييم ضرر المينا بعد إزالة اللواصق المتبقية.

النتائج : إن الأضرار السطحية للمينا التي تنتج من المواد اللاصقة لسنادات تقويم الأسنان التقليدية أعلى بكثير من تلك التي وجدت مع اللاصق الذاتي المائع في كل من السنادات المعدنية والسيراميك "المستخدمة في هذه الدراسة"

INTRUDUCTION

The objectives of debonding are to remove the attachment and all the adhesive resin from the tooth and to restore the tooth surface as closely as possible to its pretreatment condition without inducing iatrogenic damage to it. While a strong and reliable bond to enamel is desirable to prevent the premature loss of brackets, high bond strength also increases the likelihood of damaging the tooth surface during the debonding process [1]. To achieve these objectives, correct bonding and debonding techniques are of fundamental importance. There are several factors involved in this procedure, the most important of which are the instruments used for bracket removal, the armamentarium for resin removal, and the type of adhesive used [2].

The acid etched/composite technique has been widely adopted in contemporary orthodontic practice. However, this system still has a number of shortcomings, including the loss of enamel after acid etching, potential enamel fractures during the debonding procedure, and enamel damage caused by post-debonding cleanup procedures[3].

The self-etch orthodontic adhesives when introduced were considered a viable alternative to conventional three steps composite, particularly since it offered a simpler and less sensitive technique.

Several complications have been encountered during debonding of brackets than the such as enamel tears out, enamel fractures, enamel cracks, and bracket failure [4,5,6].

The amount of enamel damage was related to the type of bracket, bracket base design, and adhesive system used [7,8,9].

To reduce the rate of irreversible enamel surface damage, several methods of debonding of brackets have been suggested. These include: conventional methods in which pliers or wrenches are used, an ultrasonic method that requires the use of special tips, and electro thermal methods that involve transmission of heat to the adhesive through the bracket. Although all three methods have been used successfully to debond brackets, the use of pliers to apply shear or tensile force is perhaps the most convenient and the most popular. Improvements in bracket engineering, debonding methods and debonding instruments have been made, yet enamel damage during the debonding (especially in ceramic brackets) continues to be a matter of concern for the clinician [10,11].

MATERIALS AND METHODS

eighty premolars, extracted for orthodontic purpose, were selected for this study after examination with 10X magnifying lens [12] and transillumination light to be grossly intact, with no enamel cracks, caries, restorations, or surface irregularities, and without any pretreatment with chemical agents such as hydrogen peroxide [13,14].

The teeth were cleaned and stored in normal saline containing 1%thymol, at room temperature 37°C [15].

Retentive wedge shaped cuts were made along the sides of the roots of each tooth to increase the retention of the teeth inside the self-cured acrylic blocks [16].

Three teeth were fixed in marked position on a glass slide in a vertical position, 2cm apart, using soft sticky wax at the apex of the root , so that the middle third of the buccal surface of each tooth was oriented to be parallel to the analyzing rod of the surveyor to kept the buccal surface of tooth parallel to the applied force during the debonding test [17].

Then 2 L-shaped metal plates, were painted with a thin layer of separating medium and placed opposite to each other in such way to form a box around the vertically positioned teeth with the crowns protruding .The powder and liquid of the cold cured acrylic were mixed and poured around the teeth to the level of the cementoenamel junction of each tooth [18,19].

After setting of the cold cured acrylic resin, the L-shaped metal plates were removed,and simple adjustment of the acrylic blocks was done using the portable engine.

The 80 premolar teeth were randomly divided into 4 groups (two group for metal bracket and two group for ceramic brackets) containing twenty teeth each according to the type of brackets adhesives (conventional and self etch).

Group A: The metal bracket cemented on the teeth using conventional adhesive system.

Group B: The metal bracket cemented on the teeth using self ecthed flowable adhesive system.

Group C: The ceramic bracket cemented on the teeth using conventional adhesive system.

Group D: The ceramic bracket cemented on the teeth using self ecthed flwable adhesive system.

The buccal surface of each tooth was polished using non-fluoridated pumice with a rubber cup attached to a low speed handpiece for 10 seconds [11,20], then each tooth was washed with water spray for 10 seconds, and dried with oil-free air for 10 seconds [19].

For group A and C: The enamel on the buccal surfaces of the teeth was etched with 37% phosphoric acid gel for 30 seconds, rinsed for 30 seconds, and dried with air spray for 10 seconds [21]. The commercial adhesive resin (Oromco company) was used and both bonding liquid and composite adhesive were cured for 20 seconds. Each bracket was positioned in the middle third of the buccal surface and parallel to the long axis of the tooth, pushed firmly toward the tooth surface, and then the excess resin was removed.

For group B and D: The self ecthed adhesive resin (Vertise flow/Kerr company) was used in the same manner of group A regarding position and angulation, but without using of etch or any conditioners.

Immediately after bonding ,a constant load (200 gm) was placed on the bracket for 10 seconds [11] to ensure that each bracket was seated under a constant force and to ensure a uniform thickness of the adhesive [22,23,24].

The specimens were kept in a medium containing normal saline with thymol at 37°C for 7 days [25].

Before the beginning with mechanical debonding, each specimen was placed into a vise that positioned the tooth surface parallel to the direction of force application.

Mechanical debonding methods:(figure 1):

Bracket removal with the ligature wire cutter that placed at the base of the bracket, and a slight amount of squeezing pressure applied to the handles of cutter until debonding occurred [2].

Fig.1: mechanical debonding using ligature wire cutter.

Before removing excess adhesive and polishing the enamel surfaces, each tooth was assessed with the adhesive remnant index (ARI) in which the debonded bracket and the enamel surface of each tooth were inspected under a stereomicroscope (magnification 20X) with the following classifications: 0, no adhesive on the tooth surface; 1, less than half of the adhesive on the tooth surface; 2, more than half of the adhesive on the tooth surface; and 3, all adhesive remaining on the tooth surface [27 ,28 ,29,,30].

The residual adhesive was removed with a 12-bladed tungsten carbide finishing bur with a low-speed handpiece and air as coolant, one bur was used for each group and the specimens were cleaned with pumice and water by using rubber cups [10].

Stereomicroscope was used to evaluate enamel surface damage after the removal of residual adhesive. Photographs of post treatment enamel surface taken at 40X magnification for the two bonding techniques. The images captured by the stereomicroscope transferred to a computer. Then analyzed and assigned a score to each photo according to the following scale ***(Kitahara-Céia et al, 2008):*****0,** enamel surface free from cracks or tear-outs; **1,** enamel surface with cracks***;* 2,** enamel surface with tear-outs***;* 3,** enamel surface with cracks and tear-outs.

Statistical Analysis

All the data of the sample were subjected to computerized statistical analysis using SPSS version 15 (2006) computer program. The statistical analysis included:

- descriptive statistics including frequency, percentage and statistical table
- inferential statistics which include Chi square test

RESULTS AND DISCUSSION:

Adhesive Remnant Index (ARI)

Stainless steel bracket groups **(table 1)**:

***Group* A:** using conventional adhesive showed (score 0) in 20% of teeth, (score 1) in 40% of teeth and (score 2) in 20% of teeth. Score 3 appeared in 20% of teeth.

Group B: The ARI indicated that there is 80% of this group showed a failure site at bracket /adhesive interface and this could be related to a weak interlocking of adhesive material to the coarse mesh retentive mean at bracket base, which is even higher than that found between the self-etched flowable composite and enamel surface resulting in only 20% of this group failed at the enamel / adhesive interface.

As reflected by the ARI scores, a larger resin remnant was left on the enamel surface with the flowable composites after debonding((highly significant increase in ARI score), compared with conventional composite meaning that the primary failure site for the self-etched flowable composites was within the material or at the bracket composite interface.

Moreover, the retention of the adhesive to the enamel surface, by etching, and to the bracket base, by coarse mesh retentive mean, is greater than that within the adhesive itself resulting in about 60 % of this group failed within the adhesive material itself (score 1&2).

Table 1. Frequency Distribution of ARI for Stainless steel brackets groups.

Score	ARI	
	St. St.	
	Group A	***Group B***
0	**4**	**0**

1	**8**	**2**
2	**4**	**2**
3	**4**	**16**
Total	**20**	**20**

X^2= 15.467, d.f. =3, p-value= 0.001 (HS)

Ceramic bracket groups **(table 2)**:

Group C: The ARI after using conventional adhesive showed (score 1) in 40% of teeth, (score 2) in 30% of teeth and (score 3) appeared in 30% of teeth. Score 0 not showed in this group.

Group D: 70% of teeth revealved score 3 while only 30% showed score 2 and 1 and as with group C score 0 not showed in this group

As reflected by the ARI scores, a larger resin remnant was left on the enamel surface with the flowable self-adhesive composites (significant increase in ARI score) after debonding, compared with conventional adhesive (only 30% of score 3) meaning that the primary failure site for the flowable composites was within the material or at the bracket composite interface.

Table 2. Frequency Distribution of ARI for Ceramic brackets groups.

Score	**ARI**	
	Ceramic	
	group C	***Group D***
0	**0**	**0**
1	**8**	**2**
2	**6**	**4**
3	**6**	**14**
Total	**20**	**20**

X^2= 7.2, d.f. =2, p-value= 0.027 (S)

Enamel surface damage evaluation

The results are given in **Table (3&4)** that demonstrates scores of enamel damage for all groups of [stainless steel& ceramic] brackets.

Table 3. Frequency Distribution of enamel surface evaluation for Stainless steel brackets groups.

Score	**Enamel Damage**	
	Stainless steel	
	Group A	**Group B**
0	**16**	**18**
1	**2**	**1**

2	2	1
3	0	0
Total	20	20
X^2= 2.118, d.f. =2, p-value= 0.347 (NS)		

Table 4. Frequency Distribution of enamel surface evaluation for Ceramic brackets groups.

Score	Enamel Damage	
	Ceramic	
	Group C	group D
0	16	18
1	2	2
2	0	0
3	2	0
Total	20	20
X2= 0.784, d.f. =2, p-value= 0.676 (NS)		

The enamel damage scores showed no significant differences for both stainless steel and ceramic groups, but with some notes. The number of enamel cracks and tear out that result from debonding of stainless steel brackets that bonded with conventional was as double as that bonded with self adhesive bonding material, while for ceramic brackets; the enamel cracks was the same for both types of bonding materials with absence of tear out in the group that bonded with self etch materials. Conventional adhesive with ceramic brackts showed 10% of maximum enamel damge (score 3) that not present in any other group on this study.

In general the enamel damage including cracks and tear out was less with the use of self etch adhesive (group B and D).

The bond failure patterns for the flowable composites were potentially favorable for enamel preservation. The enamel fractures and damage tend to increase with an ARI score of 0 or 1; in other words, the fracture occurred at the enamel-adhesive interface(12). Conversely, an ARI score of 3, meaning a bonding failure at the bracket-adhesive interface, produces a low frequency of enamel fractures(26). Therefore, a bond failure at the bracket-adhesive interface would seem to be more desirable to minimize the enamel fractures(12,26). In this study, the self etch adhesives produced significantly higher ARI scores than conventional adhesive, that make the self etch flowable adhesives more favarable regarding enamel preservation. The mechanical properties of flowable composites have been reported to be inferior to those of restorative composites because of their comparatively lower filler loading

[27,28].Thus, for restorative applications, this lower filler content and resultant weaker mechanical properties may limit their clinical use. Conversely, the lower mechanical properties of flowable composites may be beneficial for preserving enamel in the case of orthodontic bracket bonding, as reflected
by the ARI scores in this study. Thus, the conventional adhesive can provide more stable bonding between the bracket and a tooth[28]. it may not be optimal in terms of enamel fractures. Therefore, great care is required to avoid damaging the enamel surface during debonding
Therefore, it would seem that the lower mechanical prperties for the self adhesives flowable adhesives were not because of a weak bond with the enamel, but rather a consequence of their comparatively inferior mechanical properties.[12,27,28]

CONCLUSIONS:

1. When considering the ARI and enamel damage scores obtained in this study, self etch flowable composites can be effectively applied to orthodontic bracket bonding.
2. use of self etch flowable adhehesive with stainless steel brackets is favarable for structurally damaged teeth, non vital teeth, teeth with cracks, heavy caries and large restorations; this may decrease the incidence of enamel fracture at debonding**.**

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