Assessment of Enamel Surface after Debonding of Different Types of Esthetic Brackets (An *In Vitro* Study)

Ghaith M. Hasan, B.D.S. [(a)]
Dhiaa J. N. Al-Dabagh, B.D.S., M.Sc. [(b)]

ABSTRACT

Background: Debonding orthodontic brackets and removal of residual bonding material from the enamel surface include critical steps that may cause enamel damage. The aim of the present study was to evaluate and compare the site of bond failure and enamel surface damage after debonding of three types of esthetic brackets (composite, ceramic, sapphire) bonded with light cure composite and resin-modified glass ionomer adhesive.

Materials and methods: Seventy two maxillary premolars teeth were divided into three groups each group consisted of 24 teeth according to the type of brackets. Each group was subdivided into two subgroups (12 teeth for each) according to the bonding material that was used. After 7 days of bonding procedure, the brackets were debonded using specifically designed debonding device in which the brackets were debonded by a debonding pliers to simulate the actual clinical debonding procedure. Instron Universal testing was used to apply the debonding force on the debonding pliers which transferred to the bracket. The teeth and the brackets were examined with a 10X magnifying lens to evaluate the site of failure. After the removal of residual adhesive, stereomicroscope was used to evaluate enamel surface damage.

Results: The most common type of bond failure was cohesive failure (Score II) in all esthetic brackets. While enamel cracks (scale I) were found to be the most type of enamel damage. Chi- square showed non-significant differences among different types of esthetic bracket bonded with same type of adhesive and between the same types of brackets (ceramic, sapphire) bonded with the two types of adhesive. On the other hand, there was significant difference between composite brackets subgroups bonded with the two adhesives.

Conclusion: The bond failure mostly within the adhesive itself and higher enamel damage was resulted from mechanical debonding of these esthetic brackets.

Key words: Esthetic bracket, Resin modified glass ionomer cement, Bond failure, Enamel damage. **(J Bagh Coll Dentistry 2016; 28(4):162-167)**

INTRODUCTION

The request for esthetic orthodontic appliances is growing and the advance of materials that present satisfactory esthetics for the patients and an acceptable clinical enactment for clinicians is looked-for [(1)].

At the beginning of 1970s, plastic brackets were sold as the esthetical substitute to metal brackets. But they suffer from three largely unresolved problems: staining, poor dimensional stability and friction between bracket slot and metal arch wire [(2,3)].

Ceramic brackets which were first made available commercially in the late 1980. Several ceramic brackets are available, all of which are composed of aluminum oxide. Polycrystalline are made of fused aluminum oxide particles. Single crystal sapphire is harder and has higher tensile strength than polycrystalline alumina [(4,5)].

When the bracket is debonded, not only some adhesive remnants stay on the enamel surface, but enamel fracture can occur at the moment of debonding. This kind of enamel fracture causes plaque accumulation on the rough fractured surface and stain [(6-8)].

Clinically, reports of bracket fracture and enamel surface damage that occur during debonding of ceramic brackets continue to be a matter of concern to clinicians [(9,10)].

The amount of enamel damage was related to the kind of bracket, bracket base design, and adhesive system used [(11,12)].

Most manufacturers now offer debonding pliers that has unique features engineered into the bracket to help in debonding. An alternative is to use thermal or laser instrument to weaken the adhesive to induce failure within the bonding agent itself [(13)].

Bonding agent is defined as a material that, when applied to surfaces of substances, can join them together, resist separation, and transmit loads across the bond. Available bonding agents for orthodontic use include, in addition to the conventional auto curing composite resins, light-curing composite resins and glass-ionomer cements, as well as hybrid materials comprising glass-ionomer and composite components (resin-modified glass-ionomers)[(14)].

[(a)]M.Sc. Student Department of Orthodontics, College of Dentistry, University of Baghdad.
[(b)]Professor Department of Orthodontics, College of Dentistry, University of Baghdad.

In the direct bonding technique, the material is cured under the brackets by transillumination because the structure of the teeth transmits visible light and by direct illumination from different sides [15].

Introduced resin-modified glass ionomer cements (RMGICs) which set through a combination of acid–base reaction and photochemical polymerization [16]. Resin-modified refers to all cements in which the acid–base reaction of true glass-ionomer cements is supplemented by a polymerization reaction [17].

In their simplest form, resin modified glass ionomer are glass ionomer cements with the addition of a few amount of a resin such as hydroxyethyl methacrylate (HEMA) or Bis – GMA in the liquid as a co-solvent [18,19].

There was no any Iraqi study regarding debonding of esthetic bracket to assess adhesive remnant index with subsequent evaluation of enamel damage that may occur specially after bonding with a new adhesive material (light cure resin modified glass ionomer capsule), so it is intended to implement the current study to establish baseline data regarding that.

MATERIALS AND METHODS

Seventy two maxillary premolars were selected for this study after examination with 10Xmagnifying lens 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 [20-22]. Three types of Roth orthodontic esthetic brackets were used in this study: Composite bracket with bonding base has three dove tail grooves and the surface area of the bracket base is 16.95 mm^2 Ceramic brackets with bonding base has three dove tail grooves and the surface area of the bracket base is 16.95 mm^2 Sapphire brackets with bonding base is coated with zirconia powder creating millions of undercuts that mechanically lock with the bracket adhesive and the surface area of the bracket base is 13.862mm^2,as provided by the company (Ortho Technology Company, USA).

After extraction, the teeth were washed and stored in normal saline containing crystals of thymol in closed container at room temperature (27° C ± 3), and that was change weekly to prevent dehydration and bacterial growth until preparation and testing[23].

The samples were divided into three groups each group consist of 24 teeth according to the type of brackets that were used (composite, ceramic, sapphire), then each group was subdivided according to the bonding material into: 12 teeth which were bonded by GC Fuji Ortho LC Capsule (GC Japan)and took the color code (R, Red) and12teeth which were bonded by light cure composite (Orthotechnology, U.S.A) and took the color code (B, Blue).

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 [24,25]. The glass slide placed on the table, each tooth was fixed in marked position on a glass slide in a vertical position using soft sticky wax at the apex of the root so that the middle third of the buccal surface was oriented to be parallel to the analyzing rod of the surveyor**.** This kept the buccal surface of tooth parallel to the applied force during the debonding test[26].Two other teeth were fixed following the above mentioned procedure with 2cm apart between them on the same glass slab. The occlusal surfaces of the three teeth were oriented to same height by cutting from the root apices using a stone disc bur. The L-shaped metal plates, were painted with a thin layer of separating medium (Vaseline) and placed opposite to each other in such way to form a box around the vertically positioned teeth with the crowns protruding**.**

Powder and liquid of the cold cured acrylic were mixed and poured around the teeth to the level of the cemento-enamel junction of each tooth [27].After setting the cold cured acrylic resin, the L-shaped metal plates and the sticky wax used for fixation of teeth in the proper orientation was removed, simple adjustment of the acrylic blocks was done using the portable engine to adjust the acrylic. After mounting, the buccal surface of each tooth was polished for 10 seconds**.**

Two types of etchant agent were used in bonding procedure, the first one was phosphoric acid gel (Pulpdent Co., U.S.A) used with composite light cure adhesive this was done for 30 seconds with a disposable brush for each tooth, according to the manufacturer instructions. Then it was sprayed with water for 30 seconds and dried with air spray for 10 seconds to give the chalky white color appearance [28]. The second one was polyacrylic acid conditioner (SDI Co., Australia) used with resin modified glass ionomer cement according to the manufacturer instructions then rinse thoroughly.

After that each bracket was positioned in the middle third of the buccal surface and parallel to the long axis of the tooth, and then pushed firmly toward the tooth surface using a clamping tweezers and bracket positioner. A constant load 200 gm was placed on the bracket for 10 seconds to ensure that each bracket was placed under an equal force and to ensure a uniform thickness of the adhesive [29]. The same procedure done for the light cure composite adhesive system except that Fuji Ortho LC capsule was mixed according to the manufacturer instructions and apply to the moist teeth (water used for moisturing applied with disposable brush).

After completion of the bonding procedure the specimens were put in a medium containing normal saline with thymol at 37°C for 7 days [30].

Debonding done byan apparatus especially designed to get the gingivo-occlusal directed force to simulate the normal clinical application of the debonding procedure with crosshead speedof0.5mm/minute [31]. Each debonded bracket was kept in a labeled container until the time of examining the adhesive remnant index (ARI).

The debonded brackets and the enamel surface of each tooth were inspected under10X magnifying lens to assess the amount of adhesive remaining on the tooth surface and the site of bond failure [32].The enamel surface was scored according to *Wang et al. classification*[33] as following:

Score 1: Failure between bracket base and adhesive.
Score 2: Cohesive failure within the adhesive itself.
Score 3: Adhesive failure between adhesive and enamel.
Score 4: Enamel detachment.

After that, the residual adhesive was removed with a 12-bladed tungsten carbide finishing bur (Komet Dental, Germany)**.**The enamel surface was evaluated by using stereomicroscope.

Photograph of post treated enamel surface took at 40x magnification then the image transferred to computer. Analysis and assignment scale to each photo, was done according to following scale [30]:

(0): Enamel surface free from cracks or tear –out
(1): Enamel surface with cracks
(2): Enamel surface with tear-outs
(3): Enamel surface with cracks and tear-outs.

Statistical Analyses

Data will be collected and analyzed by using SPSS (statistical package of social science) software version 20 for windows XP Chicago, USA. In this study the following statistics were used:

Descriptive statistics:

1. Frequency.
2. Percentage.
3. Statistical tables.

Inferential statistics:

1. Chi-square: To test any statistically significant differences among groups and subgroups for the failure site examination results and for enamel surface damage. For the purpose of statistical analysis, the ARI scores 1and 2, as well as 3 and 4, were combined.

2. Yate's correction test used with 2*2tableand Likelihood ratio used with more than 2*2 table as alternative to chi-square when the expected value less than 5 in 20% of cells or in any cell.

The probability value was set as:
$P>0.05$ NS Non-significant
$0.05\geq p>0.01$ S Significant
$p\leq 0.01$ HS Highly significant.

RESULTS

Adhesive remnant index

Brackets bonded with light cure composite

Score II was the predominant criteria of bond failure (83.3%). Which was higher in composite brackets (91.7%) followed by sapphire brackets (83.3%) and the least was in ceramic brackets (75%)as shown in (Table.1).Non-significant differences were found among esthetic brackets.

Table 1: Frequency and percentage of adhesive remnant criteria of the three types of esthetic brackets bonded with light cure composite.

Scores		Bracket types			
		Ceramic	Composite	Sapphire	Total
I	No.	2	1	1	4
	%	16.7	8.3	8.3	11.1
II	No.	9	11	10	30
	%	75	91.7	83.3	83.3
III	No.	1	0	0	1
	%	8.3	0	0	2.8
IV	No.	0	0	1	1
	%	0	0	8.3	2.8
Total	No.	12	12	12	36
	%	100	100	100	100

Brackets bonded with light cure resinmodified glass ionomer:

Score II was the predominant criteria of bond failure (69.4) which was higher in ceramic brackets (83.3%) followed by sapphire brackets (66.7%) and the least was in composite brackets (58.3%). as shown in (Table.2).Non-significant differences were found among esthetic brackets.

Table 2: Frequency and percentage of adhesive remnant criteria of the three types of esthetic brackets bonded with light cure resin modified glass ionomer

Scores		Bracket types			
		Ceramic	Composite	Sapphire	Total
I	No.	1	0	3	4
	%	8.3	0	25	11.1
II	No.	10	7	8	25
	%	83.3	58.3	66.7	69.4
III	No.	0	4	1	5
	%	0	33.3	8.3	13.9
IV	No.	1	1	0	2
	%	8.3	8.3	0	5.6
Total	No.	12	12	12	36
	%	=100	100	100	100

Evaluation of enamel surface

Brackets bonded with light cure composite:

Scale I was the predominant (55.6), which was higher in ceramic (58.3%) and in composite brackets (58.3%) and the least was in sapphire brackets (50%) as shown in (Table.3).Non-significant differences were found among esthetic brackets.

Table 3: Frequency and percentage of enamel surface damage criteria of the three types of esthetic brackets bonded with light cure composite

Scale		Bracket types			
		Ceramic	Composite	Sapphire	Total
0	No.	5	5	5	15
	%	41.7	41.7	41.7	41.7
I	No.	7	7	6	20
	%	58.3	58.3	50	55.6
II	No.	0	0	0	0
	%	0	0	0	0
III	No.	0	0	1	1
	%	0	0	8.3	2.8
Total	No.	12	12	12	36
	%	100	100	100	100

Brackets bonded with light cure resin modified glass ionomer:

Scale I was the predominant (55.6), which was higher in composite (58.3%) and in sapphire brackets groups (58.3%) and the least was in ceramic brackets (50%) as shown in (Table.4).
Non-significant differences were found among esthetic brackets.

Table 4: Frequency and percentage of enamel surface damage criteria of the three types of esthetic brackets bonded with resin modified glass ionomer

Scale		Bracket types			
		Ceramic	Composite	Sapphire	Total
0	No.	5	4	5	14
	%	41.7	33.3	41.7	38.9
I	No.	6	7	7	20
	%	50	58.3	58.3	55.6
II	No.	1	1	0	2
	%	8.3	8.3	0	5.6
III	No.	0	0	0	0
	%	0	0	0	0
Total	No.	12	12	12	36
	%	100	100	100	100

DISCUSSION

Adhesive remnant index:

Score II was the predominant site of bond failure in composite and ceramic brackets. This might be due to the type of retention means present in the base of these brackets which are dovetail with horizontal and vertical grooves allowing easy penetration of the adhesive between them into the undercut areas with good air evacuation from peripheries preventing air entrapment, therefore better mechanical inter-lock could be obtained and the retention of the adhesive to the etched-enamel in brackets bonded with light cure composite and the use of enamel conditioner in bracket bonded with light cure resin modified glass ionomer cement lead to create thick and deep resin tags, in addition to that the presence of chemical bond between the resin modified glass ionomer cement and the enamel structure this came in agreement with Al-Ibrahim [34], so higher mechanical retention was obtained between adhesive and enamel surface than within the adhesive itself this agreed with the finding of Maijer and Smith[35].

Regarding sapphire brackets cohesive failure (score II) that occurred might be due to the presence of zirconia particles coating the bracket base leading to the creation of millions undercuts that secure the bracket in its place, so increasing the adhesive – brackets retention to the level that prevent complete detachment of adhesive from the brackets base came in agreement with Garma et al [36], and the retention of the adhesive to the etched-enamel in bracket bonded with light cure composite and to the conditioning enamel in bracket bonded with resin modified glass ionomer cement is greater than that within the adhesive itself.

Evaluation of enamel surface:

Regarding light cure composite:

Scale I (enamel cracks) appeared mostly, this might be due to the retention of the adhesive to the etched-enamel (thick and deep resin tags) and strong bond between bracket base and adhesive, so highest value of shear bond strength applied to bonded bracket was required during debonding.

Light cure resin modified glass ionomer capsule:

Scale I was the predominant type of enamel damage this might be due to the use of enamel conditioner (poly-acrylic acid) produce deep penetration of resin modified glass ionomer cement tags inside the enamel, therefore better mechanical retention between adhesive and enamel surface will be resulted and the presence of chemical bond between the adhesive and the enamel structure (chemical retention), so this type of failure associated with highest value of strength applied to bonded bracket. The conclusions that could be obtained from this study were:

1. ARI showed statistically non-significant differences among different types of esthetic bracket (composite, ceramic, sapphire) bonded with same type of adhesive.
2. Score II (cohesive failure) was the most predominant type of ARI of all tested esthetic brackets which indicate the most failure site occur usually within adhesive itself.
3. Regarding enamel damage in all the tested esthetic brackets, there were non-significant differences among the different types of esthetic brackets with same type of adhesive and among the same types of brackets with different adhesive.
4. Higher enamel damage specially scale I (enamel surface with cracks) result from mechanical debonding of the tested esthetic bracket (composite, ceramic, sapphire) with the two types of the adhesive (light cure composite, light cure resin modified glass ionomer capsule) that used.

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