Laboratory Evaluation of Shear Bond Strength of Three Different Bonding Systems for Orthodontic Brackets

Ahmed Ragab Elkalza[1], Dawlat Mostafa[2]

ABSTRACT:

Objectives: *The aim of this study was to evaluate the shear bond strength of three different types of bonding systems for orthodontic brackets to tooth surface.* ***Materials and Methods:*** *Sixty sound premolar teeth divided randomly into three groups of 20 each. In group A, the brackets were bonded using conventional etch system. In group B, brackets were bonded using self-etch primer system, while in group C, brackets were bonded using one step adhesive system. Premolar teeth were mounted with cold acrylic resin in metallic mold and brackets were shear tested to failure using universal testing machine recorded in Newton for all specimens.* ***Results:*** *Group C shows significantly higher value of shear bond strength in comparison to groups A and B, while there was no significant difference between group A and B.* ***Conclusion:*** *Orthodontic brackets bonded to enamel surface using one-step bonding system (GC ortho connect) without primer was significantly higher than brackets bonded using conventional or self-etch systems.*

INTRODUCTION

The routine procedure of bonding of orthodontic brackets to enamel surface produces promising adhesive results. However, it is a procedure that includes several steps starting with acid etch, primer application and adhesive which leads to time consumption.(1-6)

The first one to use phosphoric acid with 85% concentration was Buonocore. This technique was an important advance in bonding orthodontic brackets, but the honey combed structure was not obtained in enamel prisms after etching and bracket retention was not successful. Higher bond strength was achieved by the use of 50% phosphoric acid according to investigations done by Retief et al. Nowdays, 35-38% of phosphoric acid is effective by changing enamel surface characteristics and providing micro-mechanic bond strength.(7,8)

It was mentioned previously that etching time less than 10 seconds and more than 60 seconds does not produce enough shear bond strength and etching time of 15-30 seconds is accepted as ideal working time.(9)

Failure of orthodontic brackets and the need to replace them increased expenses in term of materials and time of treatment. Brackets that remain in patient's mouth from beginning of treatment till stage of debonding leads to reduced treatment time and better results. Ideal adhesive should be able to withstand intraoral forces throughout period of treatment and causes no damage to enamel surface at time of debonding.(10)

For more than four decades, researchers have been working to improve the bonding of orthodontic brackets. Recent advances introduced self etching primer (SEP). It has been mentioned that self etching primers result in short enamel tags, but at the same time produced adequate shear bond strength of orthodontic brackets after enamel conditioning with SEP and less adhesive remnants on enamel surface after debonding.(11)

Combining conditioner and primer into one single step improves bonding time and reduces steps during bonding procedures and cost with similar or even higher bond strength. In addition, using self etching primer system decreases risk of saliva contamination.(12)

1- Lecturer of Orthodontics, Faculty of Dentistry, Alexandria University, Egypt.
2- Lecturer of Biomaterials, Faculty of Dentistry, Alexandria University, Egypt.

There is a debate about bond strength of orthodontic brackets using self-etching primer system compared to conventional bonding system. Some studies mentioned that self-etching systems produce low bond strength but still higher than conventional systems.

Paskowsky did not find any statistical significant difference between self-etch and conventional system when studying shear bond strength. On the contrary, Bishara assumed that bond strength of orthodontic brackets bonded by using self-etching primer system is higher compared to conventional system. Difference in results of several studies may be affected by many factors such as selected specimens, type of brackets, bracket retention mechanism, debonding procedure and type of adhesive used.[13,14]

Murfitt stated that self-etching primer had a significant higher bond failure rate compared to conventional etching system. Other investigations concluded that there was no statistical difference between self-etch and conventional etching systems for bracket failure.[10,15,16]

After successful tests in japan, GC company decided to launch (GC ortho connect), a new orthodontic light cured adhesive for orthodontic brackets where there is no need to apply primer on enamel surface as it is already incorporated into the paste. This bonding paste contains phosphoric ester monomer and it contributes to the stable bond and there is no need for separated primer. It also has optimal fluorescence so bonding remaining on the teeth after debonding can be detected by irradiation with light curing device.

A study was done to compare the adhesion properties of this new one step adhesive and conventional etching system as a collaboration between university of siena, Italy and university of Belgrade, Serbia and this study concluded that there was no statistical significant difference in bracket shear bond strength between the two systems. No further studies have been conducted to evaluate this novel one step adhesive bonding system, which necessitates performing the present comparable study to assess the shear bonding strength of the novel one-step adhesive compared to both self-etching primer and conventional bonding systems of orthodontic brackets.

MATERIALS AND METHODS

Sixty sound (maxillary and mandibular, first and second) premolar teeth extracted from orthodontic patients were stored in distilled water and randomly divided into 3 groups of 20 each. The teeth were selected according to the following criteria: intact buccal enamel surface, not subjected to any pretreatment chemical agents, and no caries or cracks resulted from extraction forceps.

Assuming area under ROC to be 0.08, an alpha of 0.05 and power of study 90.0%, a minimum sample size required was 20 sample in each group will be required.

Group A (Conventional Acid Etch system)

Buccal surfaces of the premolar teeth were acid etched with 37% phosphoric acid gel (opal etch, opal orthodontics by ultra dent) for 30 seconds, thoroughly rinsed with water and dried for 20 seconds. Opal seal, a fluoride releasing and recharging primer was applied followed by bracket bonding onto the center of the buccal surface of teeth with opal bond MV (Medium viscosity light cured bonding adhesive).

Group B (Self-Etch Primersystem)

The buccal surfaces of the premolar teeth were dried then tetric N-Bond universal (ivoclarvivadent) was applied and being rubbed for 10 seconds followed by bracket bonding onto buccal surface with Heliosit Orthodontic (ivoclarvivadent) light cured bonding adhesive.

Group C (One-Step Adhesivesystem)

The buccal surfaces of the premolar teeth were acid etched with GC ortho etching gel (GC Orthodontics) for 30 seconds, rinsed and dried then the bonding surface of the brackets coated with GC Ortho connect (GC Orthodontics), placed on tooth surface and light cured for 20 seconds according to manufacture recommendations.

Shear Bond Strength Test:

The premolar teeth were mounted with cold cured acrylic resin in a metallic mold using a mounting jig for aligning their buccal

surfaces with the bonded brackets to be parallel to the applied force during the shear bond strength testing procedures. The brackets were shear tested to a failure using the universal testing machine (AG-IS, SHIMADZU, Japan) to produce a shear force at the tooth-brackets interface through the application of an occlusogingival load with a crosshead speed pf 1 mm/min. The shear force producing failure was recorded in Newton for all specimens and the representing graphs were automatically displayed by the computer soft ware system. (Fig 1,2)

Statistical analysis of the data:

The data was collected and entered into the personal computer. Statistical analysis was done using statistical package for social science (SPSS/version 21) software. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. For comparison between more than two groups, ANOVA test was used for parametric data followed by post hoc test to determine the difference between each two groups. The level of significance was 0.05.

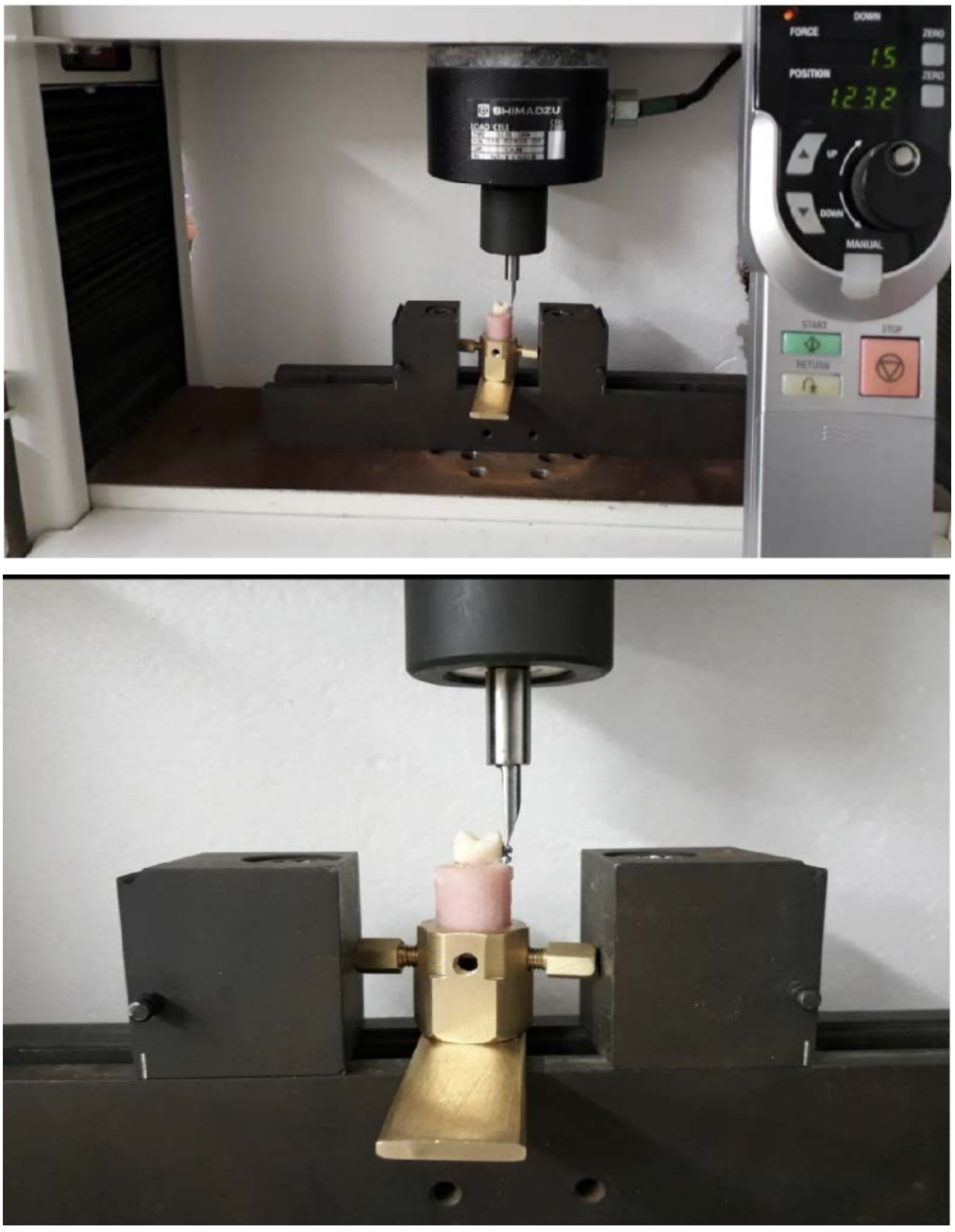

Fig (1,2): Brackets were shear tested to failure using universal testing machine (AG-IS, SHIMADZU, Japan)

RESULTS

The descriptive statistics comparing the shear bond strength of the three groups are given in Table 1. The results of the shear bond strength for the three groups using ANOVA test, followed by post hoc test indicated that, the shear bond strength was 59.55±6.39 Newton in group A (conventional Acid-Etch system), while in group B (Self-Etch Primersystem) was 56.25±15.98 Newton and in group C (One-Step Adhesivesystem) was 191.3±12.49 Newton. On comparing the three groups, there was a significant difference between group C and both groups A and B, where group C showed the significantly highest values.While there was no significant difference between group A and group B.Graphs showing the failure shear load in Newton for the studied groups are shown in figure (3,4,5).

Table (1): Comparison between the three studied groups regarding the force.

	Group A	**Group B**	**Group C**
Range	50 - 68	32 - 87	172 - 209
Mean	59.55	56.25	191.3
S.D.	6.39	15.98	12.49
F		18.25	
p		0.001*	
P1		0.1982	
P2		0.001*	
P3		0.001*	

P1 comparison between group A and group B *P2 comparison between group A and group C* *P3 comparison between group B and C*

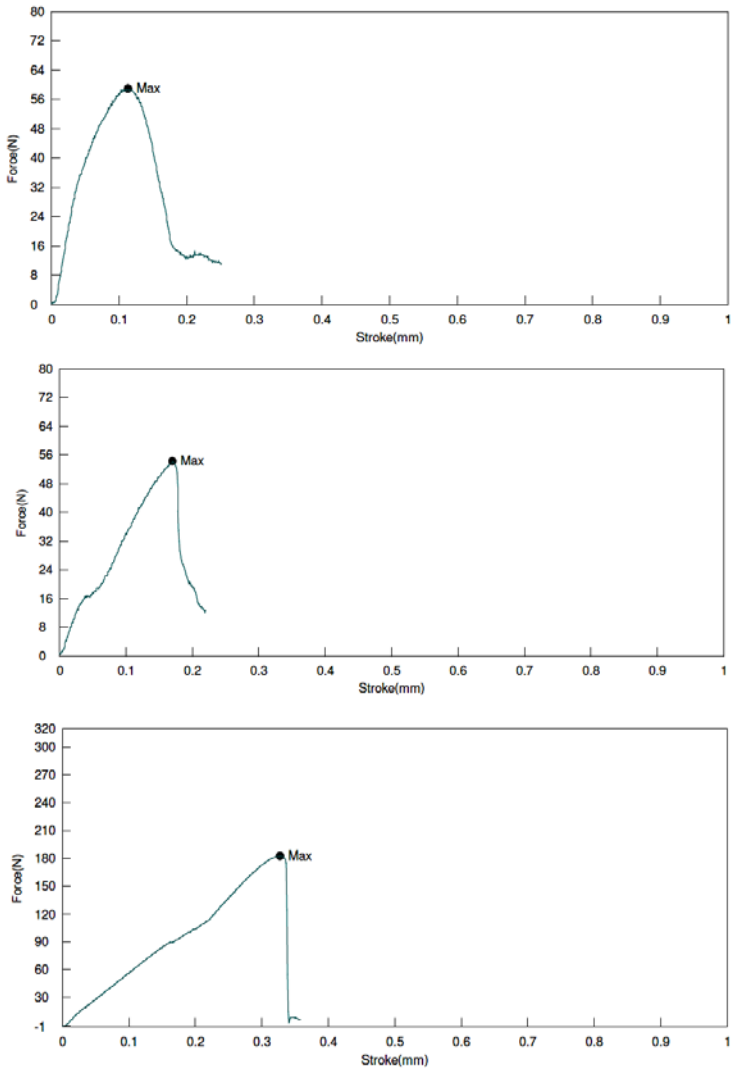

Fig.(3,4,5): Shear Load in Newton that causing failure for group A (conventional Acid-Etch system), group B (Self-Etch Primersystem) and group C (One-Step Adhesivesystem)

DISCUSSION

Although clinical orthodontic practice has been improved by direct orthodontic bracket bonding, improvement of bonding procedures by saving time and cost is definitely needed. Recent bonding systems are reliable but the need to minimize technique sensitivity and reduce the chair time by decreasing the number of steps during the bonding procedure is still needed. Conventional use of acid etchant followed by primer application was an essential procedure for bonding composite for good penetration of enamel surface.

The use of self-etching primers for orthodontic procedure by combining the etchant and the primer in one step to make handling of adhesive systems more simplified has not yet been fully evaluated. Clinically, good bond between the brackets and enamel surface is mandatory, but as fixed orthodontic appliances are temporary, methods that avoid damage to enamel surface during bonding and following debonding are desirable. Self-etching primers provide gentle etching pattern and prevent decalcification that can take place by phosphoric acid application.

The results of the present study showed that there is no significant difference between conventional bonding and self-etching primer system.These results coincide with some studies which mentioned that the shear bond strength of conventional etching is higher than that in self-etching primer, with no statistical significant difference between the two methods. The results of those studies are different from the results of studies carried out by Bishara et al, which revealed that the bond strength of conventional etching is significantly greater than self-etching primer system[17]. On the other hand, Buyukylmaz et al, reported that the bond strength of conventional etching is less than the self-etching primer system[18].

Bishara et al, indicated that the shear bond strength of self-etching primer is sufficient when used to bond orthodontic brackets, when applied to human molar enamel surface for 15 seconds before bracket bonding, which is different from the manufacturer's suggested time[2].

Gilmour et al, mentioned that the shear bond strength for brackets bonded with self-etching primer was almost one-quarter less than that of brackets bonded with conventional etching system which was statistically significant[19].

A study performed by Murfit et al, House et al, Ireland et al, found that orthodontic brackets bonded with self-etching primer showed high bond failure rates as compared with conventional acid etching, while Dos Santos et al came up with different results. They found that self-etch primer failure rates were lower compared to conventional acid etching[10,20,21,22].

A research was done in the department of medical biotechnologies, University of Siena, Italy on the adhesive properties of GC ortho connect for bonding orthodontic brackets without the use of primer. Its results showed that "one-step" resin composite for orthodontic bracket bonding that does not need the application of a primer after enamel etching achieved early bond strength similar to those of conventional etch followed by primer application and self-etching primer systems.

Differences regarding bond strength results found by various researchers may be due to different specimens selected (human or animal teeth and anterior or posterior teeth), study design (in vitro versus in vivo), surface preparation, types of adhesives, technique of debonding, the time lapse between bonding and debonding and finally the storage condition of teeth during the study period.

CONCLUSION

The mean shear bond strength of brackets bonded with novel one-step system without primer was significantly higher than those bonded with multi-step and self-etch primer systems which showed no significant difference.

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