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A COMPARISON OF THE EFFICACY OF A PRIMERLESS ORTHODONTIC BONDING ADHESIVE AS COMPARED TO CONVENTIONAL MATERIALS: AN INVITRO STUDY

Yashpal[1], Prasad Chitra[2]
[1]Dental Officer, Haryana, India
[2]Professor & Head, Army College of Dental Sciences, Andhra Pradesh, India

ABSTRACT

Introduction: Light cured composite resins have become the method of choice in orthodontic bonding procedures worldwide. In recent years, a new primerless orthodontic bonding composite, Heloisit® with good bond strength, fluoride release and an advantage of not requiring use of a primer has been introduced. **Aims of the study:** To compare the bonding characteristics of commonly available self and light cured adhesives with the Heliosit ®primerless bonding system. **Materials and Methods:** One hundred twenty extracted human premolar teeth were mounted on similar sized aluminium blocks filled with acrylic resin and were divided into four groups of thirty teeth each. All teeth were bonded with four different bonding systems Group i) Light Cured Primerless orthodontic Composite (Heliosit®, Ivoclar Vivadent, Schaan, Liechtenstein), Group ii) Light Cured Composite Resin (Transbond XT®, 3M Unitek), Group iii) Light Cured GIC (GC Fuji Ortho LC®, GC Corp.), Group iv) Self Cured Composite Resin (Rely-A-Bond®, Reliance, Inc., Illinois, USA) using metallic premolar first premolar brackets (0.022" Ortho Organizers). These were evaluated for shear bond strength using an Instron testing machine. Surface characteristics after debonding were studied under scanning electron microscopy (SEM) and evaluated using the adhesive remnant index (AR Index). Results: Shear bond strength (SBS) of primerless orthodontic light cured Heliosit® composite was clinically significant and adequate for clinical use. It lies intermediate to Transbond XT light-cured composite and Light Cured GIC. The least bond strength was shown by Rely-a-Bond® self-cured composite resin. **Conclusions:** Heliosit® light cured primerless orthodontic composite can be used for everyday clinical use due to its ideal characteristics of sufficient bond strength and reduced chances of enamel damage at debonding. Additionally, it is primerless and saves valuable clinical time.

Keywords: Adhesives, SEM, SBS, ARIndex

INTRODUCTION

The clinical practice of orthodontics has been revolutionized by advances in dental materials in recent years. This began with the introduction of adhesives by Buonocore[1]. As new adhesives were being introduced, questions like clinicians being able to determine which changes were innovative or which were just new names for the same bond strengths? Were laboratory tests good predictors of clinical performance? What was the upper limit of bond strength that minimized enamel damage at debonding?[2]

The most common problem faced by orthodontists worldwide is the retention of fixed appliances on the surface of enamel during the course of orthodontic therapy. The quest to overcome shortcomings of conventional filled composites has led to the development of flowable composites. They merit great attention due to good clinical characteristics. Heliosit® (Ivoclar Vivadent), a primerless orthodontic bonding composite has been scarcely studied. Unique properties of a primerless system include increased clinical handling time, adequate bond

Corresponding Author:
Prasad Chitra
E-mail:
prasadchitra@yahoo.co.uk
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strength, non stickiness, adequate working time and short curing time. One step of applying primer to the etched enamel surface as well as to the underside of the bracket is eliminated giving the orthodontist extra clinical working time and rebonding costs. Self cure composites in orthodontics have an inherent disadvantage of short working times and inadequate bond strengths. Light cured composites in most instances require the use of a primer which significantly increases the chair side time. To negate these difficulties, a new light cured orthodontic bonding composite, Heliosit® was introduced. The main advantages of using this material are reduced chair times for bonding since there is no primer required, adequate working time and fluoride release giving additional protection against caries.

The aim of this in vitro study was to evaluate shear bond strength and debonding characteristics of Light Cured Primerless orthodontic Composite (Heliosit®, Ivoclar Vivadent, Schaan, Liechtenstein) with other standard orthodontic bonding systems like Light Cured Composite Resin (Transbond XT®, 3M Unitek), Light Cured GIC (GC Fuji Ortho LC®, GC Corp.) and Self Cured Composite Resin (Rely-A-Bond®, Reliance, Inc., Illinois, USA) under common standard etching conditions. The null hypothesis generated was that there would be no difference in shear bond strength or adhesive remnant index score and enamel surface after debonding of the four tested groups.

MATERIALS AND METHODS

The sample consisted of 120 human maxillary premolar teeth that had been extracted as part of orthodontic treatment. Only intact, noncarious, nonrestored teeth with no developmental defects on the facial surface were used. These samples were collected and stored at room temperature in distilled water which was changed periodically to inhibit bacterial growth. Each sample was embedded in an aluminium block filled with acrylic(polymethyl methacrylate) so that only the coronal portion of the specimens was exposed. The samples were randomly divided into four groups- Groups I, II, III and IV; each group having thirty samples. The teeth were polished using a rubber cup and a nonfluoride glycerin-free polishing paste, washed and air dried.

All teeth were etched using 3M Scotchbond Etchant (3M ESPE Dental products, St Paul, Minn) containing 35% phosphoric acid. Etching procedure was carried out for 15 seconds. Metal maxillary first premolar brackets (12.2mm^2) were bonded onto the specimens (0.022" Ortho Organizers) after washing and air during the teeth.

The bonding sequence for the 4 groups was as given under:

Group I (n=30): Acid etched for 15 seconds, washed, dried, Primerless composite (Heliosit®) applied, bracket bonded and light cured for 40 seconds.

Group II (n=30): Acid etched for 15 seconds, washed, dried, Primer, Transbond XT composite applied, bracket bonded and light cured for 40 seconds.

Group III (n=30): Acid etched for 15 seconds, washed, dried, light Cured Glass Ionomer Cement (GC Fuji Ortho LC®) applied, bracket bonded and light cured for 40 seconds.

Group IV (n=30): Acid etched for 15 seconds, Primer, Self Cured Composite Resin (Rely-A-Bond®) applied and bracket bonded.

In all cases, the brackets were bonded on the teeth with firm pressure and excess adhesive removed from around brackets. All the procedures were done by a single operator to avoid interoperator variability. After bonding, the specimens were stored in distilled water at 37°C until testing.

Method of Shear Bond Strength Evaluation

The Shear Bond Strength (SBS) of bonded teeth was tested using an Instron Universal testing machine (CHYD/PTC/UTM/3, Shimadzu, Japan) with an occlusal-gingival load applied to the bracket, producing a shear force at the bracket tooth interface. A steel rod with a flattened end was attached to the crosshead of the Universal testing machine. The crosshead speed was 1.0 mm per minute with a range of 0-50KN and accuracy of 0.01N. The shear bond strength was measured in Megapascals (MPa). (Fig.1)

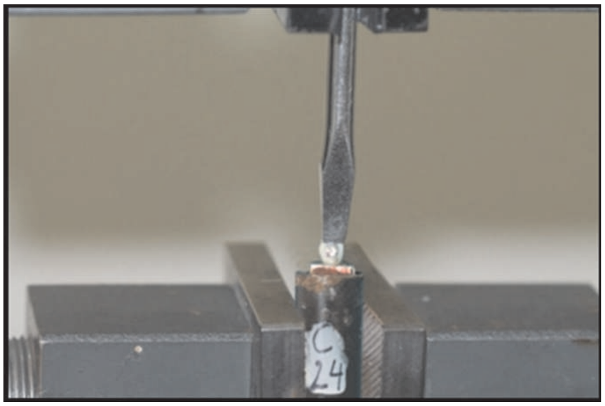

Figure 1: Instron Machine Testing Sample (CHYD/PTC/UTM/3SHIMADZU JAPAN)

Adhesive Remnant Index[3]

Once the brackets were debonded, the enamel surface of each tooth was examined under 10 X magnification to determine the amount of residual adhesive remaining on each tooth. A modified Adhesive Remnant Index (ARI) score was used to quantify the amount of remaining adhesive using the following scale: 1= all the adhesive remained on the tooth, 2= more than 90% of the adhesive remained on the tooth, 3= between 10% and 90% of the adhesive remained on the tooth, 4= less than 10% of the adhesive remained on the tooth, and 5= no adhesive remained on the tooth.

Scanning Electron Microscopic evaluation

Teeth in each group were examined under scanning electron microscope (SEM) in order to observe enamel surfaces after debonding. Specimens were mounted on aluminum stubs with carbon cement. They were then sputter coated with gold and observed at an accelerating voltage of 20 kV and a working distance of 13–14 mm. Micrographs were taken at different magnifications.

STATISTICAL ANALYSIS

Descriptive statistics including the mean, standard deviation and minimum and maximum values were calculated for each of the four groups tested. The analysis of variance (ANOVA) was used to determine the mean comparison of shear bond strength (SBS) and AR Index among the groups (statistically significant if $P<0.05$). Unpaired t test was performed to determine whether there were any statistically significant differences between groups. The statistical analyses were performed using SPSS 12.0.1 for Windows (SPSS Inc, Chicago, III) software.

RESULTS

Shear bond strength

Means (N and MPa) and standard deviations are listed in Table1. Transbond XT (light cure) composite showed the highest mean Shear Bond Strength value followed by Light cure GIC. This was followed by Heliosit primer less light cure composite and last by, the least Shear Bond Strength was shown by Rely-a-Bond (self cured) orthodontic composite. Numerical data were subjected to one way analysis of variance (ANOVA) shown in Table 2. The results are statistically significant ($F=32.463$, $P<0.05$). Unpaired t test (Table 3) was done for shear bond strength comparison between the four groups. Mean comparison between Heliosit and Rely-a-Bond was significant (t value = 2.748, p value = 0.008), mean comparison of shear bond strength between Heliosit and Transbond XT was significant (t value = 7.426, p value = 0.000), mean

Table 1: Mean value of shear bond strength of all four tested groups (n=30).

Groups	Minimum	Maximum	Mean	Sd
HELIOSIT®	5.02	8.68	7.40	1.00
TRANSBOND XT®	6.93	10.82	9.33	1.01
GIC LC®	5.21	10.36	7.81	1.30
RELY-a- BOND®	4.75	7.81	6.73	0.89

Table 2: Mean comparison of shear bond strength amongst groups

Groups	Minimum	Maximum	Mean	Sd	F value	P value
1. HELIOSIT®	5.02	8.68	7.4	1.00	32.463	0.000 Significant
2.TRANSBOND XT®	6.93	10.82	9.33	1.01		
3. GIC LC®	5.21	10.36	7.81	1.30		
4.RELY-a- BOND®	4.75	7.81	6.73	0.89		

Statistical Analysis: ANOVA one way test. Statistically significant if P<0.05

Table 3: Mean comparison of shear bond strength between groups

Groups	Mean	Sd	Mean±Sd Diff	T value	P value
HELIOSIT®	7.40	1.00	0.67±0.11	2.748	0.008 Significant
RELY-a- BOND®	6.73	0.89			
HELIOSIT®	7.40	1.00	1.93±0.01	7.426	0.000 Significant
TRANSBOND XT®	9.33	1.01			
HELIOSIT®	7.40	1.00	0.41±0.30	1.363	0.178 Not significant
GIC LC®	7.81	1.30			
RELY A BOND®	7.40	1.00	1.93±0.01	10.598	0.000 Significant
TRANSBOND XT®	9.33	1.01			
RELY-a- BOND®	6.73	0.89	1.08±0.41	3.765	0.000 Significant
GIC LC®	7.81	1.30			
TRANSBOND XT®	9.33	1.01	1.52±0.29	5.075	0.000 Significant
GIC LC®	7.81	1.30			

Statistical Analysis: Unpaired t test. Statistically significant if P<0.05

comparison of shear bond strength between Heliosit and Light Cure GIC was not significant (t value = 1.363, p value = 0.178), mean comparison of shear bond strength was significant between Rely-a-Bond and Transbond XT and between Rely-a-Bond and Light Cure GIC (t value = 10.598, p value = 0.000, t value= 3.765, p value= 0.000) respectively. Unpaired t test also significant between Transbond XT and Light Cure GIC (t value = 5.075, p value = 0.000).

Adhesive Remnant Index (ARI) Findings

Means and standard deviation for the four groups tested are presented in (Table 4). Mean comparison of ARIndex among groups were tested by One way analysis of variance (ANOVA) shown in (Table 5). Results are statistically significant (F=16.504, P<0.05).The Unpaired t test (Table.6) was used for comparison between four tested groups (Graph 2). Results were significant except for the test between Rely-a-Bond® and Light Cure GIC® (t value= 0.699, pvalue=0.487) regarding the site of bond failure.

Table 4: Mean Value of AR Index

Groups	Minimum	Maximum	Mean	Sd
HELIOSIT®	1.00	4.00	2.40	0.89
TRANSBOND XT®	3.00	5.00	4.13	0.73
GIC LC®	1.00	5.00	2.97	1.25
RELY-a-BOND®	1.00	5.00	3.17	0.95

Scanning Electron Microscope Findings

Scanning Electron Microscopic analysis was performed after debonding at varying magnifications. Both the enamel surfaces and bracket bases were evaluated for debonding characteristics under Scanning Electron Microscope (SEM).

Table 5: Mean comparisons of Adhesive Remnant Index (ARI) amongst groups

Groups	Minimum	Maximum	Mean	Sd	F value	P value
HELIOSIT®	1.00	4.00	2.40	0.89	16.504	0.000 Significant
TRANSBOND XT®	3.00	5.00	4.13	0.73		
GIC LC®	1.00	5.00	2.97	1.25		
RELY-a-BOND®	1.00	5.00	3.17	0.95		

Statistical Analysis: ANOVA one way test. Statistically significant if P<0.05

Table 6: Mean comparisons of AR Index between groups

Groups	Mean	Sd	Mean±Sd Diff	T value	P value
HELIOSIT®	2.40	0.89	0.77±0.06	3.218	0.002 Significant
RELY A BOND®	3.17	0.95			
HELIOSIT®	2.40	0.89	1.73±0.16	8.222	0.000 Significant
TRANSBOND XT®	4.13	0.73			
HELIOSIT®	2.40	0.89	0.57±0.36	2.024	0.048 Significant
GIC LC®	2.97	1.25			
RELY A BOND®	3.17	0.95	0.96±0.22	4.419	0.000 Significant
TRANSBOND XT®	4.13	0.73			
RELY A BOND®	3.17	0.95	0.20±0.30	0.699	0.487 Not significant
GIC LC®	2.97	1.25			
TRANSBOND XT®	4.13	0.73	1.16±0.52	4.427	0.000 Significant
GIC LC®	2.97	1.25			

Statistical Analysis: Unpaired t test. Statistically significant if P<0.05

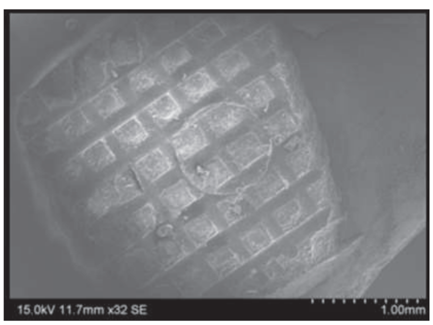

Figure 2 : Tooth surface bonded with light cured primerless composite resin Heliosit® where a type II failure can be observed.

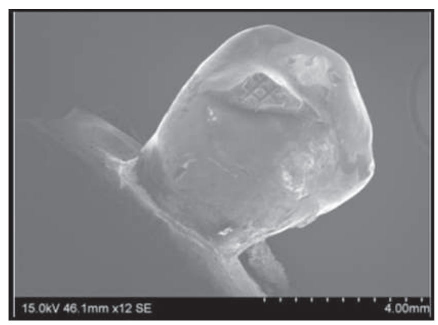

Figure 4(A): Tooth surface bonded with light cured composite resin (Transbond XT®, 3M Unitek). A type III failure can be observed.

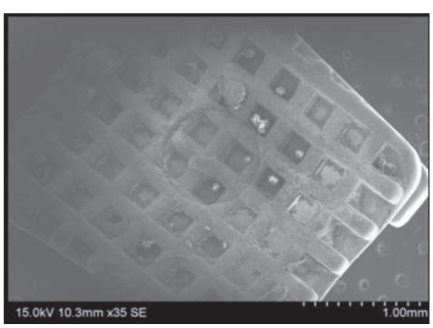

Figure 3: The bracket base after debonding when light cured primerless composite resin (Heliosit®) was used. There is no visible composite on the bracket base.

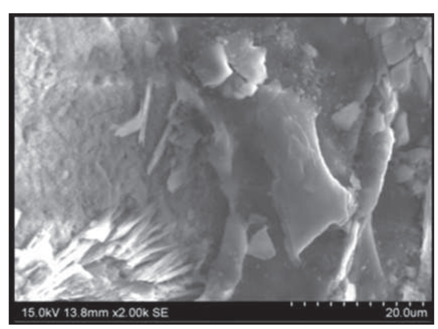

Figure 4(B): The enamel surface of the tooth at 2000X magnification with fractured enamel prisms and a porous surface.

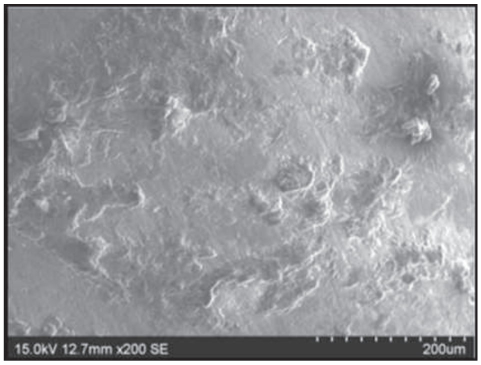

Figure 5: Tooth surface bonded with Light Cured Glass Ionomer Cement (GC Fuji Ortho LC®, GC Corp.). A type I failure with intact enamel surface can be seen at 200X magnification.

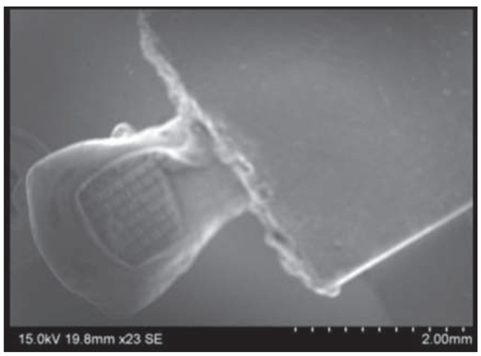

Figure 6: Tooth surface bonded with self cured composite (Rely-A-Bond®, Reliance, Inc., Illinois ,USA). A type III failure can be observed 23X magnification.

DISCUSSION

The bond strength of an orthodontic adhesive should be sufficient to withstand the forces exerted by the archwires, mechanical impact from mastication, biochemical changes in the oral cavity and also allow controlled tooth movement in three planes, so as to minimize unexpected debonding during treatment. At the same time, on completion of treatment, debonding should be hassle free with no damage to enamel. Recently, flowable composites[4] are being put to orthodontic use by many clinicians. Flowable composites provide good surface contact between bracket base and enamel better adherence at molecular levels.[4]

However, previous studies with other low viscosity adhesives are controversial regarding their clinical use with some reporting acceptable bond strength [5,6] while others did not recommend their use for direct bonding due to significantly low SBS values.[7]

Heliosit® (primerless light cured composite) (7.4MPa±1.00 MPa) showed shear bond strength less than Transbond XT® (9.33 MPa±1.01 MPa) and Light cured Glass Ionomer Cement® (7.81MPa±1.30 MPa) but greater bond strength than Rely A Bond® self cured composite (6.73MPa±0.89 MPa). .

Heliosit orthodontic composite achieves clinically significant bond strength greater than 7 MPa as suggested by Reynolds (6-9 MPa).[8,9] The bond strength achieved in our study for Heliosit Primerless orthodontic adhesive was higher than the ones achieved by Aasrum et al.[10]

Adhesive Remnant Index

In the present study, the mean value for the ARI scores of low viscosity resin (group I) Heliosit® (primerless light cured composite) was 2.40. More than 90% of the adhesive remained on the tooth. This means that the primary failure site for the composite was within the material or at the bracket composite interface.This is beneficial during debonding as there would be lesser chances of inadvertent enamel damage unlike in Transbond XT with a high ARI score of 4.13.

For (Group III) GC Fuji Ortho LC® and (Group IV) Rely-A-Bond®, ARI scores were 2.97 and 3.17 respectively.

This meant that between 10% and 90% of the adhesive remained on the tooth. Conversely, the mean value for the ARI scores of the Transbond XT® (Group II) being 4.13, indicate fractures at the enamel-adhesive interface which implies that enamel fractures and damage tend to increase.

Scanning Electron Microscopic Evaluation

Tooth surfaces bonded with Heliosit® primerless light-cured composite resin show Type II (Adhesive resin-bracket) failures (Fig.2,3). Transbond XT® had the roughest enamel surface with enamel cracks. This finding was supported by the study conducted by Martin G. et al[11] in which they claimed that the roughest enamel surfaces were obtained with Transbond XT®. Enamel tear out can be clearly perceived in the images we have obtained with Scanning Electron Microscopy (Fig.2).

SUMMARY AND CONCLUSION

The bond strength of Light Cured Primerless Composite (Heliosit®), low viscosity adhesive tested in the study was adequate and acceptable for clinical use as the value was above the clinically acceptable range. Thus, the null hypothesis was rejected. Transbond XT® had higher bond strength but caused more enamel damage at debonding. Light cured GIC also showed higher bond strength was cumbersome to use and lead to increased chair side time. The ARI score was also higher than Helosit®.

Light Cured Primerless Composite (Heliosit®, Ivoclar Vivadent) orthodontic composite has the following satisfactory characteristics

1. Clinically significant shear bond strength making routine use possible.
2. Safe debonding characteristics with no damage to enamel.
3. Increased clinical handling characteristics with adequate working time
4. Decreased chair time due to the system being primerless.
5. Decreased cost due to absence of primer application with associated steps and armamentarium.

When compared to other conventional bonding systems, Heliosit® can thus be recommended as a clinically effective orthodontic composite for everyday clinical use.

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