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A Comparison of Shear Bond Strength of two Visible Light Cured Orthodontic Adhesives -An In-vitro Study

Nilesh Suresh[1] and Navaneethan R[2]

[1]Department of Orthodontics and Dentofacial Orthopaedics Saveetha Dental College and Hospital, Saveetha Institute of Medical and Technical Sciences, Saveetha University 162, Poonamallee High Road ,Chennai-600077, Tamil Nadu,India

[2]Reader Saveetha Dental College and Hospital, Saveetha Institute of Medical and Technical Sciences, Saveetha University 162, Poonamallee High Road ,Chennai-600077, Tamil Nadu,India

ABSTRACT

The aim of the study was to evaluate and compare the shear bond strength of the brackets bonded with two different orthodontic light cure adhesives.Twenty extracted human premolars were divided into 2 groups. Premolar brackets were bonded to the tooth specimens in each group with their respective adhesive according to the manufacturer's instructions. Group1- bonded with Enlight (ORMCO) and Group2- tooth specimen bonded with Brace Paste (American Orthodontics) and then examined for shear bond strength. The teeth were placed in INSTRON universal testing machine at crosshead speed of 0.5 mm/minute, and the shear force to remove the brackets was recorded. The independent t test revealed that there was no significant difference between the shear bond strength of the two groups. The mean shear bond strengths of two adhesive systems showed no significant differences.(P value - 0.068) Thus either of the composite adhesives would provide similar results with respect to the bond strengths.

KEY WORDS: BONDING, LIGHT-CURE ADHESIVE, INSTRON MACHINE, SHEAR BOND STRENGTH, ORTHODONTIC BRACKETS.

INTRODUCTION

Bonding orthodontic brackets with visible light-cured adhesives was first reported by Tavas and Watts (O'Brien et al., 1989). Di-acrylate resin, commonly known as Bowen's reshz or bisglyceral methacrylate (bisphenol A glycidyl dimethacrylate), were designed to enhance bond strength and increase dimensional stability by cross linking, Stainless steel orthodontic brackets can be secured to teeth with this resin. The predominantly weak link in the bonding chain is at the resin/bracket base interface.

The fact that light-cured composite resins exhibit markedly less porosity than chemically cured resins have been reported by numerous authors.(O'Brien et al., 1989; Underwood, Rawls and Zimmerman, 1989; Rezk-Lega and Øgaard, 1991) The polymerization of light-activated resins under metal brackets by transillumination has been shown to be successful, because the tooth conducts visible light well enough. A lot of claims have been made that light polymerization (command curing) improves the accuracy of bracket positioning and thus minimizes the need for position in realigning of teeth after debonding (Raptis, Fan and Powers, 1979; Underwood, Rawls and Zimmerman, 1989).

The advantage of a light-cured adhesive system is that it gives the clinician the ideal working time to position the

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bracket, reduces the risk of contamination, and helps in easy removal of excess material after bonding.(King et al., 1987; Underwood, Rawls and Zimmerman, 1989) Many factors affect the retention of the brackets during fixed orthodontic treatment. (Rezk-Lega and Øgaard, 1991) However, studies have shown that clinical bond failure still occurs with 5% to 7% of brackets bonded with light cured or chemical-cured composite resins for different reasons. (O'Brien et al., 1989) (Underwood, Rawls and Zimmerman, 1989). The polymerization of light activated resins under metal brackets by transillumination has been shown to be successful, because the tooth conducts visible light well. (King et al., 1987).

Bond failures of brackets can significantly increase chair-side time, treatment time, and efficiency. Therefore, much effort has been put into improving the quality of the adhesive systems for direct bonding. Bond strength can be influenced by various factors such as light-curing devices, type of enamel conditioner, acid concentration, etching time, composition of the adhesive, bracket base design, and bracket material.(Newman, 1965)(O'Brien et al., 1989). The most commonly used adhesive systems are light-cured or chemically cured composite resins, usually combined with acid-etching. Recently a new light cured adhesive called Brace Paste was introduced by American Orthodontics.

Previously our team has done extensive research that ranged from epidemiological studies to randomised clinical trials that have been published in reputed journals. (Felicita, 2017a, 2017b, 2018; Felicita, Thirumurthi and Jain, 2017; Korath, Padmanabhan and Parameswaran, 2017; Krishnan, Pandian and Rajagopal, 2017; Charles et al., 2018; Pandian, Krishnan and Kumar, 2018; Reddy et al., 2018; Chinnasamy et al., 2019) .we have also done clinical trials on bond strength (Samantha, 2017). We wanted to compare the shear bond strength of the new adhesive- Brace Paste with that Enlight - an orthodontic adhesive produced by Ormco and hence this study.

MATERIAL AND METHODS

This study was conducted to evaluate the Shear Bond Strength of two different orthodontic adhesives used for orthodontic bonding. Twenty premolar teeth, extracted for orthodontic purposes, and free from enamel cracks, caries, and fillings were used in this research. The teeth were cleaned in water to remove any traces of blood and then they were placed in saline. Subsequently, they were stored in distilled water, which was changed at regular intervals to avoid deterioration.

They were divided into two groups:
1. Group I (n= 10) samples were color-coded with white.
2. Group II (n = 10) samples were color-coded with pink

Then teeth in each group were mounted vertically on two different color-coded acrylic boxes for identification (white- Enlight, pink - Brace Paste).

Bonding procedure: Twenty metal premolar brackets were used for the study. The base area of each bracket was calculated. Prior to bonding, the buccal surfaces were subjected to prophylaxis, polished with a rubber cup, pumice powder and rinsed with water. Etched with 37% phosphoric acid gel for 30 seconds, and then washed with water. Subsequently, the enamel surfaces were completely dried with compressed air. A thin layer of Ortho Solo (ORMCO) primer was applied to the tooth and light cured in both groups. Brackets were bonded on buccal surfaces with Enlight in group 1 and Brace Paste in group 2 according to manufacturer's instructions.

In group -1 The Enlight (Figure 1)was applied to the bracket base and then pressed firmly onto the tooth. First the mesial side was cured for 20 sec and the distal side was cured for 20 sec. Thus each bracket was light cured to a total of 40 sec with a light curing unit (Figure 3).

In group -2 The Brace Paste (Figure 2) was applied to the bracket base and then pressed firmly onto the tooth. The light curing was done similar to that of group 1

Figure 1: Enlight - ORMCO

Figure 2: Brace Paste-American Orthodontics

Bond strength test:
Group I (n = 10): 10 samples were color-coded with white.
Group II (n = 10): 10 samples were color-coded with pink

Figure 3: i.LED Light cure unit

Figure: 4 Instron Universal Testing Machine

Each group had 10 teeth which were used to carry out Shear Bond Strength testing, with the Instron universal testing machine at the cross head speed of 0.5 mm/min machine (Figure:4). The brackets were then held at their crossheads by the instron testing machine for debonding of the bracket using the instron machine and to calculate the shear bond strength. (Figure 5)

Statistical Analysis: The data obtained from the study was tabulated. The level of significance was at (0.08). The mean and standard deviation was calculated for both the groups to get the arithmetic average of the observations. Independent t-test was performed to determine the statistical difference between the shear bond strength of the two groups.

Figure 5: The brackets held at their crossheads by the instron testing machine just prior to debonding.

Table 1. Shear bond strength of Enlight – Group:1

Group-1 Enlight	Shear Bond Strength [Mpa]
1	7.22
2	8.42
3	6.63
4	5.72
5	7.35
6	8.53
7	7.14
8	6.96
9	11.13
10	8.34

RESULTS AND DISCUSSION

Shear bond strength: All data showed normal distribution and homogeneity of variances. Brace Paste had the highest shear bond strength values with a mean of 8.85 MPa (Table 3), closely followed by the light-cured adhesive Enlight with a mean of 7.74 MPa (Table 3) Light-cured Enlight had the lowest shear bond strength, lower than that of Brace Paste. In tested adhesives, the differences in shear bond strength were smaller. The results of the independent `t' test are summarized in [Table 3]. However, statistically no significant difference was found between Enlight and Brace Paste composites. Figure 6 represents the mean and standard deviation of the shear bond strength of the two composite groups (Enlight and Brace Paste). It is inferred from the chart that the Brace Paste has a higher mean shear bond strength than Enlight, but it was not statistically significant. P value - 0.068 (P>0.05)

Bonding of orthodontic brackets has become an accepted clinical technique since 1970 (Zachrisson, 1994). Bonding has largely replaced banding and is superior to banding in terms of gingival and dental health and esthetics. The bonding procedure is based on enamel alteration created by acid etching of enamel as developed by Buonocore. (Buonocore, 1955)

Table 2. Shear bond strength of Brace Paste – GROUP:2

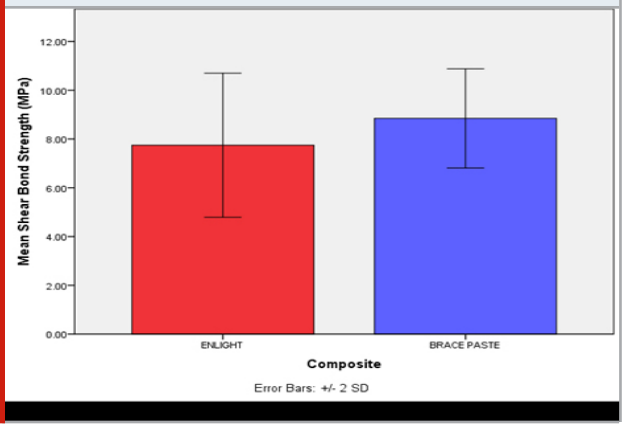
Group-2 Brace Paste	Shear Bond Strength [Mpa]
1	9.32
2	8.57
3	8.64
4	9.21
5	6.89
6	10.44
7	8.8
8	7.58
9	9.57
10	9.43

The advantages of direct bonding are easy bracket placement, acceptable clinical success rate, and reduction in chairside time. The bond failure rate is reported to vary between 0.5% and 16% which is very minimum. (Millward et al., 1997)(Bishara et al., 2007)(Sağır et al., 2013) However, this technique imposes the risk of demineralization of enamel adjacent to brackets and requires drying of the enamel surface; which is important in increasing the bond strength of brackets.(Øgaard, Rølla and Arends, 1988; Silverman et al., 1995).BracePaste® is a medium viscosity, light-curable adhesive that provides optimum bonding of metal and ceramic brackets. BracePaste is compatible with most light cure orthodontic sealants and bond enhancers. To be employed for bracket bonding a material needs to provide adhesion to the tooth surface sufficient to withstand masticatory and orthodontic forces consistently applied. The use of a bonding agent prior to bonding with composite has the advantage of immediate obliteration of enamel pores caused by acid etching that are not covered by the bracket base, thereby, preventing decalcification.

Table 3. Statistical summary of the shear bond strengths of the tested adhesives

Groups		N	Mean	Std. Deviation	Std. Error Mean
Bond Strength	ENLIGHT	10	7.7440	1.47730	0.46716
	BRACE PASTE	10	8.8450	1.01722	0.32167

Figure 6: Bar Graph showing the mean shear bond strength scores (MPa) and Standard Deviation of the two groups (Enlight and Brace Paste). The X-axis represents the two composite groups and the Y-axis represents the mean shear bond strength of the two groups in MPa. It is inferred from the chart that the Brace Paste has a higher mean shear bond strength than Enlight, but it was not statistically significant. P value - 0.068 (P>0.05).



Conventional bonding system has three different agents: the conditioner, a primer solution and an adhesive resin for the process of bonding orthodontic brackets to enamel. The use of primer was an essential part of the bonding procedure of composite adhesives to allow good wetting and penetration of the sealant into the etched enamel surface. Light cured composites are filled resin consisting of a single paste that becomes polymerized through the use of a photosensitive initiator system (CQ-Camphorquinone and amine initiator) and light source activator (visible blue light). UV light cured composite have been replaced by visible blue light activated systems with greatly improved depth of cure and controlled working time.

Exposure of light in the blue region produces an excited state of the photosensitizer, which then interacts with the amine to form free radicals that initiate additional polymerization. The free radical initiating system consisting of a photosensitizer and amine initiator is contained in this paste. Camphorquinone is a commonly used photosensitizer that absorbs blue light. Only small quantities of camphorquinone are required (0.2% or less in the paste). A number of amine initiators are suitable for interaction with camphorquinone, such as dimethylaminoethyl methacrylate, which is also present at a low level that is approximately 0.15wt%.

The mean shear bond strength of Enlight achieved in our study was 7.7440 MPa. This was lower than achieved

in some previous studies (Hajrassie and Khier, 2007) (Prietsch et al., 2007) (Northrup et al., 2007; Prietsch et al., 2007) (Bulut et al., 2007) (Bishara et al., 2007) (Schaneveldt and Foley, 2002) (Sayinsu et al., 2006) (Linn et al., 2006) (Korbmacher, Huck and Kahl-Nieke, 2006) (Korbmacher et al., 2006) (Godoy-Bezerra et al., 2006) (Cal-Neto et al., 2006) but was comparable to the studies of Tecco et al, D'Attilio et al, Rock and Abdullah (Rock and Abdullah, 1997), Sinha et al (Sinha et al., 1997), Tang et al (Tang et al., 2000), Sunna et al (Sunna and Rock, 1999; Tang et al., 2000) and Rix et al (Rix, Foley and Mamandras, 2001).

One mentioned advantage of bonding with Enlight is greater control of working time by orthodontists, which facilitates the proper placement of brackets on the teeth. (Prietsch et al., 2007) We evaluated the shear bond strengths of two common adhesive systems marketed for orthodontic bonding. In the present study, there was a slight increase in shear bond strength values of bonded brackets using Brace Paste (8.8450 MPa) compared with the light-cured composite resin Enlight (7.7440 MPa). There was no statistically significant difference in the shear bond strengths of the Enlight and Brace Paste in our study. However, the bond strengths of both the composites tested were greater than the recommended values of Reynolds. In our study Brace Paste had a slight increase in shear bond strength compared to Enlight.

CONCLUSIONS

Both the materials Enlight and Brace Paste showed no significant difference in shear bond strength. The overall bond strength and mean value for Brace Paste was slightly higher than Enlight. Therefore, Brace Paste can also be used as an ideal orthodontic adhesive in terms of increased shear bond strength, quick cure polymerization, quick cure initiator and provides faster cure. We would also recommend that these composites be tested in vivo in a randomized clinical control trial. Brace Paste, had a slightly increased shear bond strength than the Enlight.

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Conflict of Interest: There is no conflict of interest.

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