Comparison in Shear Bond Strength of Orthodontic Brackets between Biofix and Conventional Bonding Systems: An in vitro Study

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ABSTRACT

Background and objectives: The aim of the study was to evaluate the shear bond strength of brackets bonded with three bonding systems under laboratory conditions and to compare resin tag penetration after debonding.

Materials and methods: The study was done on 60 extracted human premolar teeth, divided into three groups of 20 teeth each. Each group was bonded with three different types of bonding systems namely, the single component bonding system—Biofix, conventional light cured bonding system—Transbond XT and conventional chemical cured bonding system—Unite. The shear bond strength of the bonding system in each group was tested using Instron testing machine. After debonding, the samples were sectioned and viewed under scanning electron microscope to evaluate the resin tag penetration. The depth of penetration was measured with the measuring tool in the scanning electron microscope and marked.

Results: The study revealed that the group bonded with Biofix has got the enough bond strength as the conventional chemical cured bonding system, Unite. The resin tag penetration into enamel was seen to be highest for Transbond XT, and for Biofix and Unite it was comparable and less.

Conclusion: The shear bond strength values for Biofix is above the needed value to sustain normal oral and orthodontic forces and the residual resin tag remained after debonding are also less. Hence, the single component bonding system Biofix can be considered as a good material of choice for normal clinical bonding procedures.

Keywords: Orthodontic brackets, Bonding, Composite resins, Biofix, Shear bond strength, Resin tags.

INTRODUCTION

Orthodontics typically involves the use of braces for aligning teeth. Bonding of orthodontic brackets to the tooth has been an important issue, since the introduction of bonding in orthodontics. Since then, many new bonding agents have been developed with its own merits and demerits.

Among the factors which determine the success of fixed appliance therapy, the capability of adhesive system to resist failure to forces directed to bracket-adhesive-enamel junction is very important. Orthodontic adhesives should be capable of enabling the bracket to stay bonded to the enamel for the whole duration of treatment and to permitting easy removal of brackets, when needed without damage to enamel surface. It should provide a simple way of application, convenient way of curing, and should have the potential for fluoride-release potential.

Direct bonding of orthodontic attachments was probably the most significant development in clinical orthodontics in the second half of the 20th century. In 1955, Buonocore, borrowing the techniques of industrial bonding, enhanced the adhesion with phosphoric acid. Although, it is a controversy, Newman independently claimed first direct bonding in the early 1950s.

In 1962, bisphenol A glycidyl methacrylate (BIS-GMA) resins were introduced by Rafael Brown as dental adhesives and later applied in orthodontic practice.

It was not until 1993 that the first commercial light cured product came to the market (Transbond XT Light Cure, 3M UNITEK). The same year, Watanabe and Nakabayashi developed a self-etching primer—an aqueous solution of 2% phenyl-P in 30% HEMA (hydroxymethyl methacrylate)—for bonding to enamel and dentin simultaneously. This again helped in reducing the chair side time but the bond strength was questionable. It has taken half a century for orthodontic bonding procedures to evolve from acrylic to chemically cured (2-phase, then 1) to light-cured to dual-cured (chemical light) to moisture-active to apcs.
All these bonding systems use a primer for improving the bond strength. In this study, the composite used is Biofix for which the manufacturers claim that there is no need for applying the primer separately. Biofix light cured is a single component bonding system for plastic, metal and ceramic orthodontic brackets to be fixed on dental enamel. Composition of the material is biphenyl a glicidilmethecrylate (34.78%), dimethacrylate urethane ethylene, inorganic filler (41, 52%), titanium dioxide, sodium fluoride and catalyst.

The bonding procedure and mechanism of action is similar like other light cure adhesives.

The manufacturer suggests 10 seconds curing for ceramic brackets and 20 seconds for metal brackets which again helps in reducing chairside time. The composite and primer are combined together reducing a step in chair side and thereby reducing the time and cost needed for bonding. Coupling the two in one step may affect the bond strength either advantageously or adversely. This study proposes to evaluate the shear bond strength of orthodontic brackets bonded with three different adhesive systems and to evaluate the resin penetration during bonding, thereby evaluating the efficiency of the new bonding system.

MATERIALS AND METHODS

Sixty non-carious human maxillary and mandibular premolars, extracted for orthodontic purposes, were used for this study.

Teeth were divided into three groups and assigned at random into three sets of 20 teeth corresponding to the number of adhesives tested. The groups were as follows:

- **Group 1**: Biofix (Biodinamica)
- **Group 2**: Transbond™ XT (3M)
- **Group 3**: Unite™ (3M)

Each tooth was mounted vertically in a self-cure acrylic block. Teeth were positioned with their long axis of the crown being parallel to the direction of the shear force to be applied in testing machine.

All samples were stored in deionized water at 37°C for 48 hours. Before bonding, all the required prophylaxis was done. Bondable stainless steel 0.022 slot PEA (Roth prescription) premolar brackets (American Orthodontics, USA) were used. The average bracket base area was determined to be 8.686 mm² (as prescribed by the manufacturer).

**Etching**

All samples are etched with 37% orthophosphoric acid gel (IvoclarVivadent) for 30 seconds, followed by thorough washing with abundant water spray.

**Group 1**

In Group 1, biofix (biodinamica) adhesive composite was placed under brackets and fixed to the labial surface of teeth as per manufacturer’s instructions.

**Group 2**

In Group 2, Transbond™ XT light cure orthodontic primer was applied to the tooth surface. Transbond™ XT light cure orthodontic adhesive.

Both Groups 1 and 2 were light cured with a visible light-curing unit Ortholux™ Luminous Curing Light for 40 seconds, 10 seconds per side of bracket. All the 20 samples were prepared in the same method.

**Group 3**

In Group 3, conventional self-cure Unite™ composite adhesive (3M) material was bonded as per manufacturer’s instructions.

After bonding, all samples were stored in distilled water at room temperature for 24 hours.

A universal testing machine (Instron 3365) was used for the shear bond test at a cross head speed of 5 mm per minute. In the upper jig of the instron machine, a metal string was attached, which hang down and transferred the force to the bracket. The load at bracket failure was recorded by a personal computer connected to the testing machine. The shear bond strength values were calculated in megapascals (MPa) by dividing the debonding force by the area of the bracket base.

After debonding, the teeth were sectioned and examined under scanning electron microscope (XL30, Philips, Eindhoven, The Netherlands) operated at 10 kV at magnifications of 500 times. The enamel-composite resin interface was examined for resin penetration into the enamel surface. The depth of penetration was measured with the measuring tool in the SEM and marked.

The average depth of resin penetration was noted and compared with the other groups.

**STATISTICAL ANALYSIS**

Statistical analysis was done using SPSS IBM version 20 (Chicago, USA) systems. All statistical tests were performed at a p < 0.05 level of significance.

**RESULTS**

The shear bond strength of bonded brackets with conventional light cured bonding system—Transbond XT is more than
Achieving effective and lasting shear bonding between enamel, adhesive and orthodontic brackets is essential in day to day orthodontic practice. The efficacy of direct bonding in achieving a mechanical bond requires a dry environment. Any contamination during bonding procedure compromises the bond strength completely and is considered the most common reason for bond failure.\textsuperscript{12-14} One way to overcome this problem is by reducing the chair side time and do the bonding faster. This reduces the probability of contamination.

Conventional adhesive system uses three different agents (enamel conditioner, primer solution and adhesive system). The reduction in the number of steps for bonding procedures reduces the probability of contamination during bonding and reduces the chair side time for orthodontic treatment. To simplify orthodontic bonding and to save chair time, newer materials have been manufactured.

The introduction of self etching primers reduced the clinical bonding steps and chair time, because they combine the etching and priming steps. According to studies, the shear bond strength value of self-etch primers was found to be significantly lower but acceptable. The conventional multi-step adhesives showed the highest bond strength. The self-etching primers simplified bonding procedures but caused an undesirable decrease in bond strength.\textsuperscript{15,16}

Much confusion and uncertainty surrounds the use of sealants and primers in orthodontic bonding. Research has been devoted to determining the exact function of the intermediate resin in acid etch procedure. The findings are divergent. Some investigators conclude that an intermediate resin is necessary to achieve proper bond strength: some indicate that intermediate resin is necessary to improve resistance to microleakage: others feel intermediate resin is necessary for both reasons, still others do not think that intermediate resin is necessary at all.\textsuperscript{17,18}

Acid etching causes demineralisation of the surface enamel. It removes approximately 10 μm of enamel surface and creates a morphologically porous layer (5 to 50 μm deep).\textsuperscript{19-22} The surface free energy is increased, and as a result, the low-viscosity fluid resin contacts the surface and is attracted to the interior of these microporosities created by conditioning through capillarity (capillary attraction). Therefore, resin tags are formed into microporosities of conditioned enamel that after adequate polymerization, provide a resistant, long-lasting bond by micromechanical interlocking with this tissue.\textsuperscript{23}

The bonded brackets should be able to withstand forces generated by treatment mechanics and occlusion, and it should allow easy debonding without damage to the enamel. It was also reported that a maximum tensile bond strength of 5.9 to 7.9 MPa would be adequate to resist treatment forces but in vitro tensile strength level of 4.9 MPa have proved clinically acceptable.\textsuperscript{24}

In 1975, Reynolds\textsuperscript{24} reported that shear bond strengths in the range of 5.9 to 7.8 MPa were needed to sustain normal oral and orthodontic forces. The mean bond strengths in this study were in an acceptable range, between 9 and 12 MPa (Table 1).

In this study, an in vitro bond strength characterization was chosen due to the relative simplicity, increased reliability of simulating debonding techniques and mode of load application by shear force. Shear bond strength was tested, because most masticatory forces are of a shearing nature.

The test result shows that the shear bond strength values of Biofix and Unite are comparable. The mean SBS value obtained for Transbond XT and Unite were in accordance with the previous studies.\textsuperscript{25-30}

Although, the shear bond strength values of different adhesive systems were varying in the current study, they are still in the clinically acceptable range. The single component bonding system Biofix, and the conventional chemical cure adhesive Unite are comparable in the study. Even though Biofix is a light cure bonding system and Unite is a self cure one, the shear bond strength values were in comparable range. In some previous studies,\textsuperscript{31,32} the shear bond strength values of self cure and light cure adhesives were also found to be in same range. But visible light-cured composites may have some clinical advantages over the chemically cured composites. They allow more working time which is useful in precise bracket placement, which is having much importance in the PEA system, including their relative ease of use, improved bracket placement possibilities, and faster setting of the composite.

In orthodontics, brackets and attachments are bonded for a limited time. The requirements of sufficient bond strength, ease of debonding, and limited risk of permanent damage to the enamel surface are thus critical in orthodontics.

\begin{table} [H]
\centering
\caption{Shear bond strength values}
\begin{tabular}{|l|c|}
\hline
Adhesive & Shear bond strength value (MPa) \\
\hline
Biofix & 9.3050 (SD—0.94798) \\
Transbond XT & 11.2135 (SD—1.42512) \\
Unite & 9.8985 (SD—1.59862) \\
\hline
\end{tabular}
\end{table}
The scanning electron microscopic evaluation of the deboned enamel-adhesive interface after sectioning showed the results as in the Table 2.

Resin tag penetration was comparable between Biofix and Unite (Fig. 1), but in Transbond XT (Fig. 2) group, it was found to be greater. The depth of resin tags formed is determined by pattern of acid etching, viscosity of the composite material, particle size, etc.\(^{33-35}\)

Several authors noted that there is apparently no correlation between resin tag length and bond strength of the material.\(^{35,36}\) In the current study, the resin tag penetration is more with Transbond XT (10-20 \(\mu\)m). Regular debonding with clean up rarely removes more than about 5 \(\mu\)m and there is a risk that resin tags will persist in the enamel after debonding.\(^{37}\) Although, the shear bond strength is high, the amount of residual resin tag remaining after debonding is also more for Transbond XT. Since, there is no correlation between resin tag and the shear bond strength, the residual resin entrapped after debonding and clean up can cause problems in future. These resin tags might discolor with time,\(^{38}\) and can lead to an esthetic problem to the patient later.

The adhesives with enough bond strength and lower resin penetration are thus good for both the clinician and the patient. The single component bonding system Biofix has only a resin penetration of 3 to 9 \(\mu\)m compared to the conventional light cured composites. Hence, the material can be removed by the normal debonding with clean up to a better extent.

By avoiding the contamination and performing the bonding fast and accurately could be a good solution for the current scenario. By using the new composite system Biofix, the chairside time can be reduced and will also be cost effective. The current study is in accordance with the manufacturer’s claim, that by using Biofix we can have sufficient bond strength, reduce the chair side time and cost by avoiding the primer application step.

**CONCLUSION**

- The shear bond strength of the single component bonding system—Biofix was comparable to the conventional chemical cured bonding system—Unite.
- The resin tag penetration into enamel for Biofix was found to be less than the conventional light cured composite. Hence, the residual resin after debonding on the enamel surface will be less.

**REFERENCES**

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