Evaluation of a New Nano-filled Bonding Agent for Bonding Orthodontic Brackets as Compared to a Conventional Bonding Agent: An in vitro Study

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ABSTRACT

Introduction: Recent advances in the field of material sciences have opened up a new horizon of options for bonding agents that can be used efficiently in orthodontics. The purpose of this study was evaluate and compare the shear bond strength (SBS) of the traditionally used Transbond XT and a newer nano-filled material Prime and Bond NT.

Materials and methods: Sixty freshly extracted maxillary first premolars were stored in 0.1% (weight/volume) thymol. These were divided into two Groups. Group 1: Transbond XT bonding agent and adhesive were used to bond the brackets to the premolars, Group 2: Prime and Bond NT was used as a bonding agent and Transbond XT as the adhesive. The test specimens were mounted on acrylic tubes and tested for SBS level by using universal testing machine.

Results: The SBS of Transbond XT was higher than the newer nano-filled Prime and Bond NT, but both values were above the clinically acceptable levels.

Conclusion: Although both bonding agents provide clinically acceptable levels of bond strength, the technique to bond the nano-filled Prime and Bond NT is more cumbersome as compared to the Transbond XT material, which makes the latter a more popular choice in the clinical set up. If the application procedures for the Prime and Bond NT can be simplified then it could be a convenient option in the orthodontic practice.

Keywords: Bonding agents, Shear bond strength, Nano-filled composite.


INTRODUCTION

The introduction of acid etching technique in the 1950’s to bond dental restorations to tooth structure was a breakthrough point in the history of orthodontic bonding.1-5 During mid 1950’s, there were some reports of direct bonding of orthodontic attachments to teeth with the use of epoxy resins, followed by the introduction of epoxy acrylate in the early 1960’s and utilization of bis-GMA resin composites in the mid 1960’s.6-8

With advances in dental materials and techniques, bonding of orthodontic brackets became easier and more predictable. New materials and methods of bonding to enamel and dentin have been developed in restorative dentistry that has decreased the number of steps required for the bonding procedure. The advent from two-step chemical cure to single step or direct bonding to single step light cure composites has made the bonding of orthodontic attachments simpler.9

Further improvement in the composite resin was accomplished through altered filler packing, higher filler levels and hybrid filler particles. Since the shrinkage occurs mostly in the resin matrix, it has been suggested that an effective method to control shrinkage is to reduce the resin content of the composite. This concept led to the introduction of monohybrid restorative materials using nanotechnology.10

It was found that nono-filled composites had a marginal seal in enamel and dentin comparable to total-etch adhesives, hence, their use in bonding orthodontic brackets should be explored.

AIMS AND OBJECTIVES

1. To evaluate the shear bond strength (SBS) of orthodontic brackets bonded to teeth by a conventional composite (Transbond XT, 3M Unitek).
2. To evaluate the SBS of orthodontic brackets bonded to teeth by a new nano-filled bonding material (Prime and Bond NT, Dentsply).
3. To compare the SBS of conventional material to newer nano-filled bonding material.

MATERIALS AND METHODS

Tooth Specimen

A total of 60 extracted human upper first premolars were collected and the specimens were stored in thymol solution (0.1% wt/vol).

Inclusion criteria for tooth specimen was as follows:
- Intact labial surfaces
- Specimens stored in thymol solution (0.1% wt/vol) following extraction.

Exclusion criteria were:
- Caries
- Restoration in tooth
- Gross enamel hypoplasia
- Enamel defects
- Cracking of labial enamel surfaces
- Specimen not stored in thymol solution (0.1% wt/vol) following extraction.

All teeth were examined under normal light conditions to assess suitability for inclusion. Pronounced cracking was designated as those teeth with cracks detectable by direct visual inspection.

Enamel Surface Preparation

Enamel preparation and bracket bonding was standardized in the following way:

1. Labial enamel surfaces were polished with fluoride-free pumice slurry using a rubber prophylaxis cup attached to a slow speed handpiece for 10 seconds.
2. Polished surfaces were rinsed with air/water spray for 15 seconds and dried with a stream of oil-free compressed air for 10 seconds.
3. Enamel surface was etched with 37% ortho-phosphoric acid for 30 seconds. Etchant was applied to the tooth surface with a brush and agitated during etching period. The etched surfaces were then washed with water for 15 seconds and dried with oil-free compressed air until the surface of the etched enamel has a frosted appearance.
4. Teeth were divided into two groups of 30 each.
5. In Group 1, Transbond XT primer (3M Unitek, Monrovia) was applied to the etched tooth surfaces with a brush and the tooth surface was lightly blown with a stream of oil-free compressed air to ensure that only a thin layer of primer remained.
6. An upper premolar (Roth, American Orthodontics) series bracket with a bracket base area of 10.265 mm² was used and Transbond XT adhesive was applied directly onto the bracket base. The brackets were then placed onto the already etched and primed tooth surface.
7. Brackets were bonded to the labial surface at the intersection of the long axis of clinical crown (LACC) and the clinical crown long axis midpoint (LA). Each bracket was seated directly into the correct position and force was applied. Excess adhesive was removed using a sharp probe and pressure was reapplied for 5 seconds.
8. Excessive adhesive was cleared from around the bracket periphery using a probe and the bonding material was polymerized by exposure to halogen light for 20 seconds with light intensity of 800 mw/cm² and wavelength of 400 to 500 nm (Dentsply Spectrum 800).
9. In Group 2, Prime and Bond NT was dispensed directly onto a disposable brush and applied thoroughly to wet the enamel surface such that the enamel surface should remain fully wet for 20 seconds and reapplied if necessary. Excess solvent was removed by blowing gently with air from dental syringe for at least 5 seconds till the surface had a uniform, glossy appearance and then light cured.
10. Steps 6, 7 and 8 were repeated to bond teeth in Group 2.

Tooth Mounting Preparation

The teeth with the bonded brackets were mounted in self-curing acrylic resin within plastic tube (8 mm radius, 40 mm length). Teeth in group 1 were mounted in pink acrylic and the teeth in Group 2 were mounted in clear self-curing acrylic (Fig. 1). The teeth were mounted vertically into the tube with the crowns left projecting above the rim of the acrylic up to the cementoenamel junction (CEJ) and parallel to tube walls.

Bond Strength Testing

Each acrylic block with its embedded specimen was assembled in the customized jig in the lower crosshead of the Instron universal testing machine (Lloyd Instruments, LR 50 K). The jig had a cylindrical hole (8 mm radius) into which each acrylic
block was fitted purposely to direct the applied force occlusogingivally and parallel to the labial tooth surface.

A blade (50 mm length, 10 mm breadth) was mounted on the upper jig of the Instron machine.

During testing, the Instron machine had a maximum capacity of 50 KN, maximum load cell of 500 N and crosshead speed of 5 mm/min (Lloyd Instruments LR 50K) (Fig. 2).

The force necessary to debond the brackets was recorded automatically in Newtons and then converted into megapascals (MPa) by dividing the Newtons value by the surface area of the bracket base (10.265 mm²).

**RESULTS**

**Shear Bond Strength Comparison**

Table 1 shows the SBS of the 60 test specimens. Column one shows the SBS of Transbond XT (Group 1) and column 2 shows the SBS of Prime and Bond NT (Group 2) in MPa.

The mean SBS for Transbond XT was 12.201 MPa and that of Prime and Bond NT was 11.036 MPa. The standard deviation of Transbond XT and Prime and Bond NT was 2.073 and 2.637 MPa respectively (Table 2).

Graph 1 shows that the SBS values in Group 1 ranged from a minimum of 8.066 MPa to a maximum of 14.420 MPa while in Group 2 the SBS values ranged from a minimum of 1 MPa to a maximum of 13.346 MPa. Table 2 shows the mean SBS for the two groups with their standard deviations.

The SBS was subjected to statistical analysis using software system SPSS V 13. The null hypothesis was that there is no significant difference in the mean SBS between the two groups and alternate hypothesis was that there is a significant difference in the mean SBS between two groups.

The two values were later subjected to Mann-Whitney’s U test, where p < 0.01 was set to show the level of significance that shows a mean difference of −1.166 MPa (Table 3). This test is a useful alternative to the parametric t-test when assumptions of the parametric test are not met or when measurement is on the ordinal scale. All calculations for this
test are based on ranking the scores in order, considering algebraic size. The results of the statistical analysis indicated the presence of a significant difference (p = 0.001) (Table 3).

Higher SBS was recorded in Group 1 compared to Group 2 and the SBS difference between them was not statistically highly significant as p value was 0.001.

DISCUSSION

This study was primarily concerned with the evaluation and comparison of the SBS of a new nano-filled bonding agent with a conventional bonding agent.

This study used Transbond XT bonding agent with Transbond XT adhesive which had better results than Prime and Bond NT with Transbond XT adhesive. The bond strength of the Prime and Bond NT may be less because it is supposed to wet the tooth surface continuously for 20 seconds, which is difficult to standardize.

In studies of SBS, the sample size is an additional important factor, and it was suggested that at least 20 and preferably 30, specimens should be tested if valid conclusion are to be drawn from in vitro bond strength studies.11,12 In this study 30 samples in each group were tested with a total of 60 test specimens for conclusive results.

The results of the current study suggest that both bonding agents had clinically comparable bond strengths. This can be attributed to the similarity in the application procedures as well as using the same etchant and adhesive system.

As the guidelines for bonding the Prime and Bond NT suggested that the bonding agent should fully wet the surface for 20 seconds and may necessitate additional application of mixed adhesive, it made the bonding procedure lengthy and cumbersome.

Also Prime and Bond NT required blowing air gently from dental syringe for at least 5 seconds. The force of the air could not be regularized for each test specimen bonded. This may have reduced the bond strength of the nano-filled material in our study.

The bonding procedure was easier, shorter and simpler using Transbond XT as compared to the lengthy procedure described by the manufacturers of Prime and Bond NT.

The mean SBS for Transbond XT recorded in other studies is slightly higher than that recorded in our study.10,13-15 The values still are above the clinically acceptable levels (6-8 MPa).16-20 Several factors affect bond strength of brackets, such as composite composition, photopolymerization type, bracket base morphology and exposure time. These may account for the slightly reduced SBS of Transbond XT in our study.

Future Scope for Study

In this study, adhesive remnant index (ARI) scores were not tested, hence, further studies are required to infer if brackets failed at enamel/adhesive interface or adhesive bracket interface.

CONCLUSION

The shear bond strength of Transbond XT was higher than Prime and Bond NT and the difference was statistically significant, the easier bonding procedure of Transbond XT makes it a more convenient choice in clinical practice. If the bonding procedure for Prime and Bond NT could be simplified and the primming time is reduced, the newer nano-filled material Prime and Bond NT can be a convenient substitute for the conventional bonding agent.

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