Original Article

Microshear Bond Strength of Transbond XT and Assure Universal Bonding Resin to Stainless Steel Brackets, Amalgam and Porcelain

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Abstract

Background and Aim: Assure Universal Bonding Resin is marketed with fluoride releasing potential. The manufacturer claims that it provides adequate bond strength between the bracket and amalgam and porcelain. This study compared the shear bond strength of Transbond XT and Assure Universal Bonding Resin to stainless steel brackets, amalgam and porcelain in vitro.
Materials and Methods: In this in vitro study, 20 standard brackets of the maxillary central incisors, 20 feldspathic porcelain specimens and 20 self-cure acrylic cavities filled with amalgam were divided into 2 groups bonded with Transbond XT and Assure. After surface preparation in each group, Transbond XT composite was applied to the surfaces using silicon tubes and light-cured for 20 seconds. Then, the microshear bond strength was measured using a universal testing machine. The data were subjected to two-way ANOVA, Tukey's post hoc test, Student's t-test and the Kruskal Wallis test.
Results: Different microshear bond strength values were obtained for the bond to stainless steel brackets, amalgam and porcelain by Transbond XT and Assure ($p<0.0001$). Using Assure for bonding to amalgam (7.2±1.46 vs. 10.12±4.97) and brackets (16.14±3.2 vs. 20.16±5.12; $p<0.05$) decreased the microshear bond strength compared to Transbond XT. However, Assure significantly increased the bond strength to porcelain compared to Transbond XT (28.84±6.42 vs. 22.48±3.6; $p<0.01$). Non-parametric Kruskal-Wallis test showed significant differences in adhesive remnant index (ARI) between the two bonding agents only in the amalgam group ($p=0.029$).
Conclusion: Although the bond strength values of Assure were less than those of Transbond XT, Assure was capable of providing sufficient bond strength especially to porcelain.

Key Words: Bond strength, Orthodontic adhesive, Dental amalgam, Dental porcelain, Stainless steel

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Introduction

Introduction of the acid etch technique in 1955 by Buonocore [1] enabled direct bonding of orthodontic brackets to tooth structure. Thus, orthodontic treatments were enhanced and gingival irritation was decreased. It also simplified oral hygiene maintenance, improved esthetics and decreased the duration of orthodontic visits [2]. Advances in orthodontic bonding methods decreased the need for banding of posterior teeth. Also, by an increase in number of adult patients requiring orthodontic treatment, bracket bonding to teeth with porcelain crowns and amalgam restorations emerged as a challenge. A study on recent modifications in orthodontic treatment demonstrated that molars and premolars are less frequently banded in contemporary orthodontics compared to before [3]. The currently available bonding agents require primers and thus, a proper bond to amalgam and porcelain is more time-consuming and costly. This clinical problem has triggered new investigations on the bond to amalgam and porcelain.

Assure Universal Bonding Resin is a relatively new product with fluoride-releasing potential and has been reinforced with resin cement. Assure hydrophilic resin (by Reliance) has been reported to have adequate bond strength under humid conditions [4-6]. The manufacturers claim that Assure enhances adhesion to normal enamel, atypical enamel (hypo-calcification, fluorosis), primary teeth and dentin. Moreover, it can bond to roughened surface (amalgam, gold and stainless steel) and composite with no need for an extra primer.

Assure is the first orthodontic adhesive capable of chemically bonding to stainless steel.

The manufacturer claims that Assure provides 50% higher bond strength to stainless steel compared to that by other adhesives due to the formation of a chemical bond and optimal flowability [7].

However, further studies are still required in this regard since documented evidence is lacking regarding the accuracy of the manufacturers' claims. This study aimed to compare the bond strength of Transbond XT (3M Unitek) and Assure Universal Bonding Resin (Reliance Orthodontic Products, Itasca, IL) to stainless steel brackets, porcelain and amalgam.

Materials and Methods

This in-vitro, experimental study was conducted on amalgam and porcelain specimens and stainless steel brackets. The understudy population included amalgam and porcelain specimens and stainless steel brackets prepared to assess the efficacy of Transbond XT and Assure Universal Bonding Resin via the application of Transbond XT composite. The study was conducted on 20 stainless steel brackets (n=10 in each group), 20 amalgam specimens (n=10 in each group) and 20 porcelain specimens (n=10 in each group). Sample size was calculated based on previous studies and specimens were randomly selected.

Test 1: Bond to stainless steel brackets:

Twenty standard maxillary central incisor brackets (American Orthodontics) were mounted in acrylic resin to remain fixed during the experiment. Brackets were then divided into two groups. In each group (n=10), the respective adhesive was applied to the bracket surfaces (two layers of Transbond XT group and four layers of Assure). Ten seconds time was allowed for the surfaces to dry and then Transbond XT composite was applied to the silicon tubes with an internal diameter of 0.9mm and height of 1.5mm. The tubes were placed at the center of brackets and light cured for 20 seconds.

Test 2: Bond to porcelain:

Twenty feldspathic porcelain specimens in the form of hollow cubes measuring 8x8mm and 1cm height were prepared for easy mounting in the acrylic resin. Porcelain specimens were mounted in the acrylic resin and their surfaces were sandblasted with 50µ aluminum oxide particles for three seconds and 9.6% hydrofluoric (HF) acid was applied to the surface for 2 minutes followed by rinsing and drying. The specimens were divided into two groups (n=10 each). In the Transbond XT group, Silane was applied to the surfaces followed by the application of the respective adhesive (two layers of Transbond XT and four layers of Assure). As performed in test 1 protocol using a silicon tube, Transbond XT composite was applied to the porcelain surface and light cured for 20 seconds.

Test 3: Bond to amalgam:

Using polyvinyl siloxane, an impression was made of a cube and 20 equal-size cubes were fabricated using self-cure acrylic resin. In the acrylic cubes, cavities were prepared measuring 6mm in width, 7mm in length and 2mm in depth and a retentive groove was also created in the base. Amalgam (SDI) was applied to the cavities, condensed and burnished. After 24 hours, the specimens were polished with green and brown rubber cups and stored at 37°C for 48 hours. The amalgam surfaces were sandblasted with 50µ aluminum oxide particles for three seconds and after that, the specimens were divided into two groups (n=10). In the Transbond XT group, one layer of Reliance metal primer was applied, 30 seconds time was allowed and the respective adhesives were applied to the surface of specimens in the two groups (Transbond XT in two layers and Assure in four layers). Based on the protocol described in test 1, Transbond XT composite was applied to the amalgam surface using silicone tubes and light cured for 20 seconds.

All specimens were then stored in an incubator at 37°C for one week and were then subjected to thermal cycles at 5-50°C (each cycle for 30 seconds and 15 seconds of transfer time).

Microshear load was then applied to specimens at a crosshead speed of 1mm/min with a preload of $0.1N/mm^2$ until failure using a universal testing machine (Zwick Roell, Germany). Load was measured in N and recorded. The microshear bond strength values were calculated by dividing the load at failure (N) to the area's cross-section (mm^3) in MPa. After debonding, the surface of specimens was assessed using a stereomicroscope at 10X magnification. Based on the amount of remnant adhesive on the surface, the ARI was calculated and reported using a 0-5 scoring system:

Score 5. Adhesive resin remained on 100% of the bracket, porcelain and amalgam surfaces.

Score 4. Adhesive resin remained on 75%-100% of the bracket, porcelain and amalgam surfaces

Score 3. Adhesive resin remained on 50%-75% of the bracket, porcelain and amalgam surfaces

Score 2. Adhesive resin remained on 25%-50% of the bracket, porcelain and amalgam surfaces

Score 1. Adhesive resin remained on less than 25% of the bracket, porcelain and amalgam surfaces

Score 0: No adhesive resin remained on the bracket, porcelain and amalgam surfaces [8].

Two-way ANOVA was applied to determine the effects of type of material and bonding agent on the microshear bond strength. One-way ANOVA was used to assess differences in microshear bond strength values in the two groups of Transbond XT and Assure based on the type of bonded material. If the results of ANOVA were significant, pairwise comparison of groups was done using the Tukey's test. Microshear bond strength values for bracket, porcelain and amalgam were analyzed in the two groups of Transbond XT and Assure using Student's t-test. The Kruskal Wallis test was applied to assess differences in ARI scores.

Results

The microshear bond strength values to stainless steel brackets, porcelain and amalgam are presented in Table 1.

The results of two-way ANOVA showed that the effect of type of material (stainless steel bracket, amalgam and porcelain) on microshear bond strength values was significant ($p<0.0001$) but the effects of type of bonding agent (Assure and Transbond XT) on bond strength values were not statistically significant. Also, the interaction effect of type of material and bonding agent on microshear bond strength was significant ($p<0.001$).

Statistical comparisons with one-way ANOVA revealed significant differences in microshear bond strength values among the three groups of stainless steel brackets, porcelain and amalgam when using Assure ($p<0.0001$). On the other hand, multiple comparisons by Tukey's test revealed significant differences between amalgam and bracket ($p<0.0001$), amalgam and porcelain ($p<0.0001$) and bracket and porcelain ($p<0.0001$).

One-way ANOVA showed significant differences in microshear bond strength among stainless steel brackets, porcelain and amalgam when using Transbond XT ($p<0.0001$). Multiple comparisons by Tukey's test showed significant differences in microshear bond strength between amalgam and bracket ($p<0.001$) and also amalgam and porcelain ($p<0.0001$) when using Transbond XT. However, the difference in microshear bond strength between the bracket and porcelain in use of this adhesive was not significant ($p=0.59$).

Significant differences were noted in microshear bond strength to stainless steel brackets between Transbond XT and Assure ($p<0.05$) and the microshear bond strength to bracket was significantly higher when using Transbond XT compared to Assure. Bond to porcelain was significantly higher by Assure compared to Transbond XT ($p<0.01$).

No significant difference was noted in bond to amalgam between Transbond XT and Assure ($p=0.1$).

The ARI in the three groups of stainless steel brackets, amalgam and porcelain in use of Transbond XT and Assure is shown in Table 2. Nonparametric Kruskal Wallis test revealed significant differences in ARI scores between the two bonding agents only in the amalgam group ($p=0.029$).

Discussion

Based on the results, when using Assure, ARI score was found to be zero in bond to porcelain, amalgam and stainless steel brackets. However, in Transbond XT group, although the frequency of ARI score of zero was dominant, scores 1 and 2

Table 1. The minimum, maximum, mean and standard deviation values of bond strength to amalgam, porcelain and stainless steel bracket surfaces using Transbond XT and Assure bonding agents

Material	Bonding agent	Number	Minimum	Maximum	Mean± standard deviation
Amalgam	Assure	10	4.35	8.73	7.2±1.45
	Transbond	10	5.6	20.95	10.11±4.9
Bracket	Assure	10	11.23	21.48	16.13±3.2
	Transbond	10	12.98	30.35	20.16±5.62
Porcelain	Assure	10	19.7	38.72	28.8±6.42
	Transbond	10	17.66	28.74	22.47±3.6

Table 2. The frequency of ARI scores in bonding of Transbond XT and Assure to stainless steel brackets, amalgam and porcelain

Group/ARI	Material	0	1	2	Total
Assure	Amalgam	10(100%)	0	0	10(100%)
	Bracket	10(100%)	0	0	10(100%)
	Porcelain	10(100%)	0	0	10(100%)
	Total	30(100%)	0	0	30(100%)
Transbond XT	Amalgam	6(60/0%)	4(40.0%)	0	10(100%)
	Bracket	9(90/0%)	1(10.0%)	0	10(100%)
	Porcelain	8(80/0%)	0	2(20.0%)	10(100%)
	Total	23(76/7%)	5(16.7%)	2(6.7%)	30(100%)

were also noted. This difference between the adhesives was significant in the amalgam group, indicating the stronger bond of Transbond XT adhesive to amalgam surface compared to Assure. ARI score of zero indicates pure adhesive failure at the amalgam-resin, resin-porcelain or resin-bracket interface with no fracture in the composite; similar results have been reported in previous studies [9].

Microshear bond strength to stainless steel bracket was 20.16±5.12 MPa in Transbond XT and 16.14±3.21 MPa in Assure group; this difference was statistically significant. It indicates that despite the manufacturers' claims, Assure does not chemically bond to stainless steel and the existing bond is only mechanical.

Such higher bond strength may be attributed to the size of porosities on the bracket surface and optimal consistency of Transbond XT. Based on the results of the current study, the microshear bond strength to amalgam was in the range of 5.6 to 20.95 MPa in the Transbond XT and 4.35 to 8.73 MPa in the Assure group. These values were significantly lower than the bond strength values to porcelain and stainless steel brackets. In previous studies, bracket bond strength to amalgam was reported to be significantly lower than that to enamel [9]. Considering these low values and the acceptable range of bond strength to be 5-8 MPa, the reported bond strength value to amalgam was within the acceptable range. Considering the significant difference in bond strength to amalgam surface between the two bonding agents and use of metal primer only in the Transbond XT group, Assure has the advantage of providing a low, but acceptable bond strength (higher than that in the control group) without requiring an extra primer. Bond to amalgam must also be investigated in vivo in order to be able to generalize the results to the clinical setting.

For bond to porcelain, a combination of 9.6% HF acid and sandblasting was used for surface preparation; which has been reported to be the most suitable technique for porcelain surface preparation [10]. In contrast, for composite surfaces, sandblasting and diamond bur preparation alone compared to 5% HF acid have shown more favorable results [11]. The microshear bond strength to porcelain was 22.48±3.6 MPa in the Transbond XT and 28.84±6.42 MPa in the Assure group. High bond strength to porcelain may be attributed to the application of HF acid or silane. HF and phosphoric acids have no effect on physical properties or topography of the porcelain surface but instead, they neutralize the alkaline effects of the aqueous layer on the surface of porcelain restorations in the oral cavity (if present). This mechanism increases the chemical activity of silane following application. The results of the current study indicate the importance of using silane in increasing the bond strength. This finding has also been reported in a previous study [12]. Assure has the advantage of providing a bond strength to porcelain significantly higher than that of Transbond XT without requiring silane.

In the two groups of porcelain and amalgam, microscopical porosities were created on the surfaces to enhance mechanical bonding. Thus, Assure provided more adequate bond strength due to its flowability.

Conclusion

Although the bond strength provided by Assure was lower than that by Transbond XT, it was adequate for bracket, amalgam and particularly porcelain bonding.

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