Comparison of Bond Strength between Selected Orthodontic Adhesives versus Anterior Restorative Materials

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Abstract

The objectives of this study were to measure and compare the bond strength between selective orthodontics adhesives and anterior restorative materials. 104 extracted bovine incisors were selected and divided into four groups of 26 each, etched with 37% phosphoric acid, primed with Prime & Bond One (Dentsply) and bonded in dry field to enamel surfaces using four different adhesive materials. The materials tested were: Transbond XT(3M), Lightbond(Reliance), Filtek Z350XT(3M) and Neofil (Kerr).

These samples then underwent thermal and acidic exposure for two time intervals, at twenty four hours and three months and finally the shear bond strength were measured using Instron Universal Testing machine.

The data then analysed using SPSS Compare Means Paired Sample T-Test. Lightbond (OA) showed the highest mean value of bond strength at both 24 hours and three months' time interval which was 13.95 MPa.

This followed by Transbond XT (OA) that exhibit lower value at 9.63 MPa. Filtek Z350 (AR) had the highest bond strength among the anterior restorative materials tested at 9.18 MPa while the Neofil (AR) has shown significantly lower and consistent mean bond strength in both time intervals among all materials which was 7.88 MPa.

Orthodontics adhesives have higher bond strength to bovine enamel compared to anterior restorative materials.

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Introduction

The acid etch procedure, introduced in 1955 by Buonocore, has been widely used in many areas of dentistry as quoted by Hinson.[1] One current adaptation is its use in the direct bonding of attachments for tooth movement in orthodontics.

In routine orthodontic practice, it is fundamental to obtain a reliable bond between tooth enamel and orthodontic bracket attachment. However, there was report on the usage of filled restorative materials as orthodontic adhesives among the dental practitioners, stated by Guiraldo.[2] This led to various problems such as polymerization shrinkage of the composite material that may cause gaps between the adhesive and enamel surface and lead to microleakage, thus reduce the bond strength. Guiraldo[2] also described that the gap formation permits the passage of bacteria and salivary secretions from the oral cavity which evident by increase in white spot lesions prevalence and severity with fixed appliance treatment.

Therefore, to overcome this problem, a low-shrinkage, tooth-colored nano-composite, has been introduced to the market. 3M ESPE (St. Paul, MN) has introduced silorane, a material reported to have lower shrinkage as mentioned by Chalipa et al.[3]

Despite the extensive applications of nano-composites in restorative dentistry, more

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proofs are needed on the possibility of using them for bonding orthodontic brackets. Hence, one of the aims of this study is to compare the bond strength between orthodontic adhesives and anterior restorative materials.

Materials and methods

Sample collection

104 bovine incisors were collected in this study. These teeth were extracted using an anterior forcep No. 1. Following extraction, all teeth were placed in a 10% formalin solution and stored at room temperature. The samples were then divided into 4 groups of 26 teeth each and allocated to 1 of the 4 adhesive material. Each 26 tooth sample was placed in a labelled jar containing lactic acid at pH 6.8, to simulate the slightly acidic pH of the oral cavity.

The jars were labelled according to the adhesive materials utilized. The products tested were: Transbond XT (3M), Lightbond (Reliance), Filtek Z350XT (3M), and Neofil (Kerr). All materials were received from the manufacturers within two months of testing.

Bracket Bonding

Each of the 4 adhesive materials employed an acid etching technique and used according to the manufacturer's recommendations.

At the time of bonding, each tooth was: (1) pumiced with a non-fluoridated prophylaxis paste for one minute, (2) rinsed and dried, (3) etched with the 37% phosphoric acid (4) rinsed and dried, (5) primed.

The selected adhesive was applied to the bracket base. The brackets were pressed flat against the labial tooth surface with bracket tweezer parallel to the long axis of the tooth in the mid-portion of the clinical crown. All bonded teeth were light cured for twenty seconds and allowed to polymerize for twenty minutes at room temperature to insure complete setting of all samples before being stored. The brackets used were of Pre-adjusted Edgewise Appliance of MBT prescription.

Thermal cycles

Each bonded sample was thermally cycled one hundred times from 4 °C and 60 °C at one minutes intervals, prior to testing. Thermal and drying cycling during storage would have better simulated the oral condition. After that, the sample were soaked in the lactic acid solution for twenty-four hours and three months.

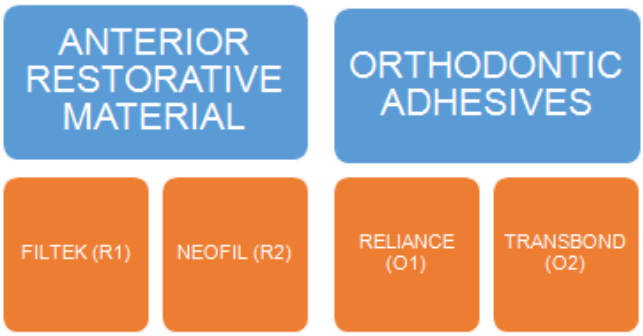

Figure 1. The materials used in our research.

Figure 2. Bonded bracket to tooth.

Bonding Strength Testing

All samples for each material were then tested with the Instron Universal Testing Instrument in the tension mode. The Instron machine was calibrated prior to each sample testing session. A fifty pound load cell and a cross head speed of 0.02 inches per minute was employed. The recording graph was operated at a chart speed of one inch per minute and a full scale definition of fifty pounds. A special harness was designed for testing the samples. A jig was fixed to the load cell which then attached to the upper member of the Instron. The sample was placed in the lower member.

The load together with the jig pushed the Pre-adjusted Edgewise bracket off. The breaking force in pounds were recorded. The data for each sample were collected and analyzed statistically using the SPSS Compare Mean-Paired Samples T-Test.

Figure 3. The teeth undergone thermal cycle.

Figure 4. The teeth immersed in lactic acid.

Figure 5. The bonding strength tested using Instron Universal Testing Machine

Results

Bonding Strength

The results of this study were recorded in the following tables and graph:

Table 1 shows mean bonding strength in MPa and standard deviation of Filtek Z350 [AR], Neofil [AR], Reliance [OA], and Transbond [OA] at twenty-four hours, three months and overall. In overall results, it showed Reliance [OA] has the highest mean bonding strength followed by Transbond [OA], Filtek Z350 [AR] and the lowest was Neofil [AR] with value 13.95 MPa, 9.63 MPa, 9.18 MPa and 7.88 MPa respectively.

Figure 6 shows the mean bonding strength in MPa of each material in 24-hours and 3 months intervals. In both time intervals, Reliance (OA) shows the highest mean bonding strength which is 14.91MPa and 12.98 MPa compared to Transbond (OA), Neofil (AR) and Filtek Z350 (AR). However, for the lowest mean bonding strength in 24-hours is Filtek Z350 (AR) and in 3 months interval is Neofil (AR) with the value of 7.27 MPa and 6.92 MPa respectively. However, Filtek Z350 showed the lowest mean bonding strength in 24-hours interval, with Neofil at 3 months interval with the value of 7.27 MPa and 6.92 MPa respectively.

Table 2 shows results of paired samples t-test within and between the groups of materials for 24-hours interval. Comparison within groups of materials consists of Filtek Z350 (R1) versus Neofil (R2) as Pair 1 and Reliance (O1) versus Transbond (O2) as Pair 2. While comparisons between groups of materials consists of Pair 3: Filtek Z350 (R1) versus Reliance (O1), Pair 4: Filtek Z350 (R1) versus Transbond (O2), Pair 5: Neofil (R2) versus Reliance (O1) and Pair 6: Neofil (R2) versus Transbond (O2). In paired samples t-test within groups, there were no significant differences between Pair 1 and 2 ($p > 0.05$). However, in paired samples t-test between groups, it showed significantly different in Pair 3, 4 and 5 ($p < 0.05$). Unfortunately, result for paired samples t-test in Pair 6 showed no significant difference ($p > 0.05$).

Table 3 shows results of paired sample t-test within and between the groups of materials for 3 months interval. Comparison within groups of materials consists of Filtek Z350 (R1) versus Neofil (R2) as Pair 1 and Reliance (O1) versus Transbond (O2) as Pair 2. While comparisons between groups of materials consists of Pair 3:

Filtek Z350 (R1) versus Reliance (O1), Pair 4: Filtek Z350 (R1) versus Transbond (O2), Pair 5: Neofil (R2) versus Reliance (O1) and Pair 6: Neofil (R2) versus Transbond (O2). In paired samples t-test within groups, it showed significantly different between Pair 1 and 2 (p< 0.05). Moreover, in paired samples t-test between groups, it also showed significantly different in Pair 4, 5 and 6 (p< 0.05). Unfortunately, result for paired samples t-test in Pair 3 showed no significant difference (p> 0.05).

	24 HOURS		3 MONTHS		OVERALL	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Filtek Z350 [AR]	7.27	3.37	11.09	1.95	9.18	2.66
Neofil [AR]	8.84	2.92	6.92	3.09	7.88	3.01
Reliance [OA]	14.91	5.09	12.98	4.29	13.95	4.69
Transbond [OA]	11.57	4.24	7.704	2.33	9.63	3.28

Key: [AR]- Anterior Restorative Material, [OA]- Orthodontic Adhesive Material

Table 1. Mean bonding strength in Mega Pascal (MPa) and standard deviation of each material at twenty-four hours, three months and overall.

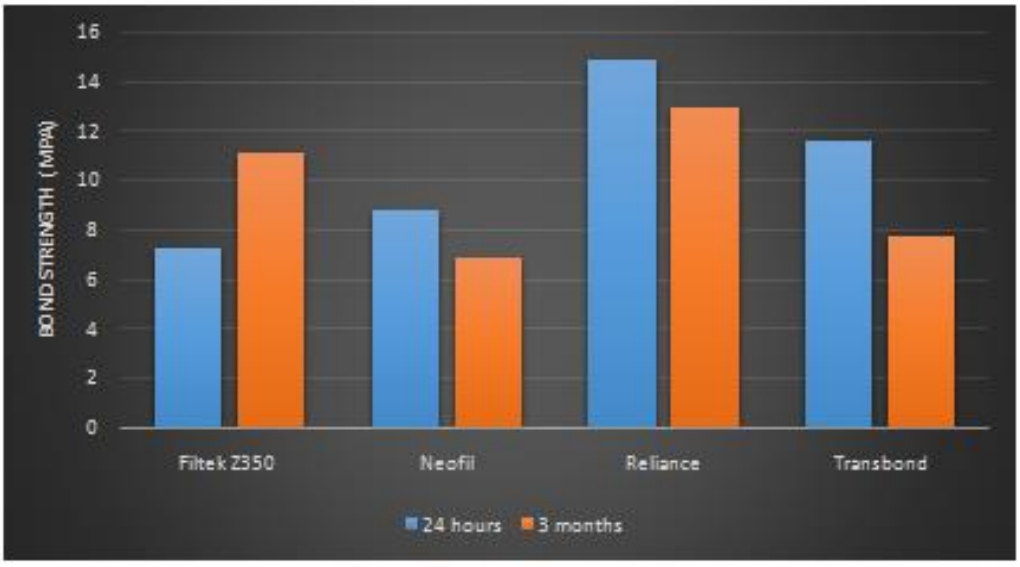

Figure 6. Mean bonding strength in MPa of each material

		24 HOURS		*p* value
		Mean	S.D.	
Within group	Pair 1: R1 - R2	-1.57	3.54	0.17
	Pair 2: O1 - O2	3.33	5.95	0.066
Between group	Pair 3: R1 - O1	-7.58	7.54	0.008
	Pair 4: R1 - O2	-4.68	5.51	0.018
	Pair 5: R2 - O1	-6.02	7.21	0.020
	Pair 6: R2 - O2	-3.11	6.37	0.13

Key: R1- Filtek Z350 , R2- Neofil , O1- Reliance , O2- Transbond

Table 2. Results of paired samples t-test within and between groups of materials and its *p* value.

		3 MONTHS		*p* value
		Mean	S.D.	
Within group	Pair 1: R1 - R2	4.69	0.73	0.000
	Pair 2: O1 - O2	5.28	1.26	0.004
Between group	Pair 3: R1 - O1	-1.89	1.24	0.15
	Pair 4: R1 - O2	3.39	0.85	0.001
	Pair 5: R2 - O1	-6.59	1.09	0.000
	Pair 6: R2 - O2	-1.31	0.45	0.016

Key: R1- Filtek Z350 , R2- Neofil , O1- Reliance , O2- Transbond

Table 3. Results of paired sample t-test within and between groups of materials and its *p* value.

Discussion

There are many dental filling and orthodontic adhesives materials available in the markets. The ideas and innovations are being realized by the companies in order to satisfy the current demands. However, the end users deserve to be treated and endowed with the best materials. Based on the result, the purpose objectives of the study are served which were to measure and compare the bonding strength between the orthodontics adhesives and anterior restorative materials for the attachment of brackets.

The result of the study revealed that the Reliance orthodontic adhesive has the highest bond strength after twenty-four hours. The materials were significantly better than other products tested. Reliance orthodontic adhesive showed a significant difference in bond strength when compared to both anterior restorative materials, Filtek Z350 and Neofill with p value < 0.05. However, another orthodontics adhesive material, Transbond XT also showed significant difference in bond strength when compared to Filtek Z350 (AR), but no significant difference at 0.05 level of bond strength when compared to Neofill (AR). There is no significant difference, when the bond strength of material was compared within the groups.

After three months, two products showed no significant difference in bond strength results which are Filtek Z350 (AR) and Reliance (OA). It is interesting to note that Filtek Z350 (AR) has higher bond strength than Transbond XT (OA) at this tested time interval as Filtek Z350 (AR) showed sign of increased in strength from twenty-four hours to three months period of time. However, both orthodontic adhesives have higher bond strength compared to Neofill (AR) and Neofill (AR) weakened somewhat from twenty-four hours to three months period.

Utilizing the Paired Sample T-test at 0.05 level, the following summation can be made (Figure 1). Reliance (OA) is the best product among those tested. Transbond XT has the lowest bond strength between the two orthodontic adhesives tested. Neofill (AR) showed significantly lower bond strength than any other products tested, a finding that is consistent at each (tested period of time) time of intervals. Markovic et al[4] stated that the initial strength is very important, as there is a time interval before stress is applied via the archwire varying from one day to one week or longer following the placement of brackets. This supported by Saleh and Taymour[5] who mentioned that a material that is initially might be weak can serve its purpose adequately as it shows an increased in bond strength value with time.

From the data collected, it is noticed that a broad range lies among the bond strength of these materials. As every product in this study is currently used by the dental professionals, one must determine the expediency of using each of these materials as bracket bonding agent as the wide variability present. Reynold[6] mentioned that the maximum orthodontic force applied are around 7.8 MPa. In this study, for each time interval, each material tested exceed the force value needed. Therefore, any of the tested materials can be used as the bracket bonding agent.

The result also, in hindsight, indicated that dental professionals should be more cautious

during debonding procedure to avoid enamel fracture, as in general higher force is needed to debond the attachment albeit we are fully aware that these were tested on bovine teeth. Anterior restorative materials tested, if we are to disregard other characteristics, could be proposed be used as an alternative adhesive to bond bracket. However, operator should be wary of higher risk of fracturing the enamel during debonding procedure as Filtek Z350 showed strengthening of it bonding in three months interval. Neofill, however, weakened by time.

Therefore, operator should choose the best materials available carefully and wisely for bracket bonding procedure. Hobson et al[7] stated that the success of any restorative intervention is mainly modified by the oral environment. It is noted that they depend on the pH fluctuation, temperature changes, and force of mastication. Thus, our main goal should be the utilization of product with maximum strength.

Conclusions

Overall, it can be concluded that Reliance XT produced the highest bond strength under the condition of the in vitro study. Both of the orthodontic adhesives showed significantly higher bond strength than anterior restorative materials. Thus, the hypothesis that orthodontic adhesive has higher bond strength than anterior restorative materials is accepted. However, the bond strength of the anterior restorative materials in this research exceeded the suggested bond strength needed in brackets adhesion.

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Conflict of Interest

The authors state that there were no conflicts of interest related to this study.

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