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CONGRESS PROCEEDING

In Vitro Comparison of Indirect Bonding Methods Using Different Isolation and Adhesive Systems with Each Other

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Abstract

Purpose of this study is to compare the shear bond strength and adhesive remnant index of a new indirect bonding isolation method for different adhesive systems with the direct bonding technique. 100 premolars and 10 incisors extracted human teeth were bonded with one direct and four indirect bonding methods, and then subjected to 1000 thermal cycles between 5°C and 55°C. Adhesive Remnant Index (ARI) was analyzed by the chi-square test. The Shear Bond strength was analyzed by the analysis of variance (ANOVA) and the Tukey multiple comparison (HSD) test. The bracket-enamel interface area of two teeth from each group was examined under scanning electron microscope (SEM). All groups provided clinically acceptable bond strengths. In the traditional isolation + light-cured bonding group with the highest bonding values identified, the scores for all failures were recorded as 3 and this group differs from all other groups in respect of ARI scores ($p<0.05$). In addition, it was identified from SEM images that there were air bubbles in the adhesive layer in the groups where chemical adhesives were used. When a tape is used as the isolation material, the laboratory process stage is shortened and simplified. Therefore, if the custom base indirect bonding technique is to be used, this new method can be used with light-cured bonding agent for isolation.

Key words: chemically cured; indirect bonding; light-cured

Introduction

The "indirect bonding technique" was firstly introduced in 1972 by Silverman et al.[1] for more accurate and effective placement of brackets on teeth. Later, Thomas[2] introduced a new method creating a custom base made of composite resin under the bracket. This method has not only allowed for an extension of the working time as desired, but also reduced the composite resin flash problems. However, the most disputed issue in this method is the possibility of the weak bonding between the adhesive and the bracket base made of composite resin customized for the patient and the possible reasons for this weakness.[3] Following their manufacture, composite custom bases are usually sanded with 50 μm aluminum oxide particles and cleaned with alcohol to get rid of oil residues and separating medium residues on the composite base.[4] Despite the known fact that any cleaning applied onto the composite resin base reduces the bonding strength of the bracket to the enamel; there has been no isolation method developed to prevent the contamination of composite resin base with undesirable substances. In addition, while there are many adhesive systems produced for use with the direct bonding technique today, the adhesive systems produced for the indirect bonding technique are limited.

The objective of this study was to identify the most suitable adhesive system that can be used with the custom base indirect bonding technique and the most appropriate isolation system by comparing two different isolation methods.

Methods

One hundreed maxillary and mandibular premolar and 10 incisor teeth without any cracks, fractures, white spot lesions, or filling on their enamel surfaces were cleaned and then stored in a 5% chloramine-T solution at 4°C for a week and subsequently in distilled water at 4 °C. The teeth were mounted in acrylic blocks in groups of 10 each with the teeth coming into contact with each other at their contact points. After taking measurements in the indirect bonding groups, 38% phosphoric acid (Gel Etching Agent,

Reliance Orthodontic Products, Inc., Itasca, USA) was applied onto the enamel surfaces of all teeth. After waiting for 30 seconds, the surface of each tooth was washed with pressurized water for 10 seconds and then dried for 10 seconds. It was observed that an opaque white area formed on the enamel after this treatment.

In the direct bonding control group, Transbond TM XT Light Cure Adhesive Primer (3M Unitek, Monrovia, CA, USA) was applied as a thin coat onto the enamel surface and bracket base, followed by the placement of Transbond XT onto the composite resin base, filling up to the half of the bracket base area; and then, the bracket was placed on the tooth surface. The composite resin was polymerized by applying plasma arc light (Apollo 95 E Denmark Technologies, Inc., USA) for 3 seconds per bracket.

In the indirect bonding group named TT (Tape + Transbond), after waiting one day for the hard plaster models to dry, stationery-type plastic clear adhesive tape was attached to the buccal surfaces of the teeth only in the plaster model for isolation purposes. After applying Transbond XT bond and Transbond XT composite resin onto the bases of the brackets, the brackets were placed on the tape-covered plaster model by applying constant pressure for 5 seconds. Following the application of plasma arc light for 3 seconds, all brackets were coated with Emiluma (Ortho Kinetics, USA) and a tray was formed with 0.40-inch-thick Essix (Raintree Essix, Inc., USA) plate. After removing the tray from the model together with the brackets, no treatment was applied except for slightly spraying air against the composite surface. After applying Transbond XT bond onto the teeth prepared as described above, the tray was positioned, and the brackets were bonded to the teeth by applying plasma arc light for 3 seconds.

In the indirect bonding group named TS (Tape + Sondhi), the steps explained above were exactly followed; but instead of Transbond XT, Sondhi Rapid set was applied according to the user company's recommendation.

In the indirect bonding group named IT (Isolant + Transbond), the steps described for the group named TT were repeated exactly; but Isolant was used for isolation of the models, and then, the composite surfaces of the tray were carefully sandblasted with 50 μm aluminum oxide particles, cleaned with alcohol, and then dried with air. In the IS (Isolant + Sondhi) group, the steps described for the group named IT were repeated exactly; but; but instead of Transbond XT, Sondhi Rapid set was applied according to the user company's recommendation.

After undergoing 1000 cycles in the thermocycling device at a temperature set between 5°C and 55°C with a dwell time of 30 seconds in each bath, the samples were stored in distilled water at 37°C for 72 hours. The speed of the upper movable table of the Instron testing machine (Hounsfield, United Kingdom) was set as 0.5 mm/minute and the measurements were made with 1N precision. Variable forces generated in response to movement at a constant speed of 0.5 mm/minute were monitored from the electronic display and the highest value of the force generated at the time of failure was recorded (Table 1). The surfaces of the teeth were examined at 30X magnification. Adhesive Remnant Index (ARI) defined by Artun and Bergland was used to define the failure sites.[5] (Table 2) The bracket-enamel interface area of two teeth from each group was examined under scanning electron microscope (SEM). The thickness of the adhesive remaining between the composite resin and enamel layers on each tooth was measured in three separate sites. A total of 30 measurements, including 6 measurements per group, were performed at 1000X magnification and the photographs of the sites of such measurements were taken. In addition, the bracket-enamel interface area was also examined at 40X magnification to examine the presence of air bubbles. All statistical evaluations were performed using SPSS (Statistical Package for Social Sciences, SPSS for Windows 10.0.1, SPSS Inc, Chicago) package program. The descriptive statistical data including mean, standard deviation, minimum and maximum values of the shear testing results in MPa were calculated for the Control, TT, TS, IT, and IS groups. The comparison of the groups was performed using the analysis of variance (ANOVA) and the Tukey multiple comparison (HSD) test. Chi-square (X^2) analysis was performed to compare the ratios of ARI scores. Kruskal-Wallis analysis of variance was used to compare the medians of three measurements made for two teeth per each of Control, TT, TS, IT, and IS groups against five groups.

Table 1. Statistical comparison of tensile test (MPa) results.

Groups	N	Mean	SD	Min	Max	Tukey Test*
Control	20	8.2	3.3	3.9	16.6	AB
TT	20	8.6	4	3.1	13.8	AB
TS	20	8.0	3.4	4.1	17.6	AB
IT	20	10.3	3.4	5.5	1.8	A
IS	20	7.1	2.7	4.0	13.8	B
		F=2.68		p=0.048		

N: Number of sampels, SD: standard deviation, Min: Minumum value, Max: Maximum value *Groups shown with different letters differ statistically significantly.

Table 2. Distribution of ARI scores and results of x^2-square test

Groups	N	1	2	3	4	5
Control	20	0	8	11	1	0
TT	20	1	3	11	3	2
TS	20	0	3	12	5	0
IT	20	0	0	20	0	0
IS	20	0	1	14	5	0
		x^2 = 36.301		p=0.003		

Results

The data were evaluated using ANOVA and in the comparison of the stress measurements of the groups, the difference between the groups was found to be significant ($p<0.05$). As a result of the Tukey test, the difference between the IT group and the IS group was found significant ($p<0.05$). When the adhesive remaining on the enamel surface was evaluated under a stereo light microscope, it was determined that there were statistically significant differences between the groups (X^2=36.301, p=0.003). The difference between the IT group and all other groups was found to be statistically significant ($p<0.05$). In addition, there was a significant difference identified between the control group and the IS group ($p<0.05$). While all of the failures observed in the IT group occurred at Score 3, i.e. on the composite resin; the failures in the other groups varied with different scores.

In the comparison of the findings obtained from the analysis of adhesive thicknesses under SEM, there were significant differences between the direct bonding group and all other groups ($p<0.05$). In addition, the difference between the TT group and the TS group and IT group and the difference between the TS group and the IS group were found to be significant ($p<0.05$). However, the difference between the TT group and the IS group was found to be insignificant ($p<0.05$). In addition, it was identified based on the SEM images that there were air bubbles in the adhesive layer in the TS and IS groups.

Discussion

While custom base technique offers the advantage of easy removal of adhesive remnants after bonding of the brackets, it also has a disadvantage caused by the formation of an interface layer between the old composite resin and the new adhesive.[3] The adhesive systems

other than thermosetting adhesive systems are basically systems produced for use with the direct bonding technique. Besides the advantages of chemically-cured adhesives such as ease of use, easy learning of the system, and quick working capability, it is stated that they also have some disadvantages such as limited working time, excessive polymerization shrinkage occurring due to the internal stresses caused by sudden onset of polymerization, and reduced bond strength due to the entrapment of air bubbles in them during mixing in dual-cure systems.[6] While the biggest advantage of light-cured adhesives is the ability to control their polymerization times, it has been reported that the length of exposure times of these adhesive systems might pose a disadvantage in a clinical setting.[7]

In this study, Transbond XT primer adhesive was preferred in the control group (direct bonding) and the two indirect bonding groups due to its compatibility with Transbond XT composite resin to make a comparison with Sondhi Rapid-Set adhesive system. A clear full arch tray was used since this primer has a light-cured structure to better represent the mouth environment. Silicone-based Emiluma, a transparent material produced to form trays in the indirect bonding technique only, was used as the tray material. Since this material has a light body consistency, the stability was assured by forming a second tray using thermoplastic material.

The new isolation method that we used in our study was the isolation of the plaster model directly with clear tape. The advantage of this isolation method is that there is no waste of time for cleaning after the removal of the tray from the model, thus eliminating the risk of damage to the composite resin custom base likely to be caused by cleaning. In this isolation method that we apply, the composite resin that will form the custom base is polymerized by remaining between the clean tape and the bracket base. The bonding strength of the composite resin to the tape is high enough to keep the brackets fixed on the model during the formation of the tray. In contrast, a slight mechanical force is sufficient to remove the tray from the model when desired. As a result of this study, only the 3rd indirect bonding group for which Transbond XT primer adhesive was used was found to have a higher bond strength compared to the 4th indirect bonding group for which Sondhi Rapid Set was used as the adhesive system. No statistically significant differences were identified in the other comparisons between groups. The 4th indirect bonding group was the group with the lowest average bond strength of 7.1 MPa. The lower values required for clinical success in the literature vary in the range between 5.9 and 7.8 MPa. Even the 4th indirect bonding group has satisfied these clinically acceptable bond strengths.

No statistically significant differences were identified between all the other indirect bonding groups and the direct bonding group. However, in both indirect bonding groups in which Transbond XT was used as adhesive, the bonding values were found to be higher than the direct bonding group for which the same material was used. Although these high values were not found statistically significant, we can say that the indirect bonding method is at least as reliable as the direct bonding material since the same adhesive materials were used in all of the three groups. This finding is also consistent with many other studies. There is no statistically significant difference between the direct bonding group and the 2nd indirect bonding group for which Sondhi Rapid Set was used as adhesive, either. When the values obtained are reviewed regardless of the isolation method, it is observed that the average bond strengths in the groups using Sondhi Rapid Set as adhesive are lower than the groups for which Transbond XT adhesive primer was used. We think that this was caused by the air bubbles that we have identified in the groups for which Sondhi Rapid Set was used, as shown by the SEM examinations.

Considering ARI score values that we have obtained in our study, failures are mostly of cohesive nature. In the IT group with the highest bonding values identified, all failures were found to be at score 3 and this group differs from all other groups in terms of ARI scores ($p<0.05$). The IT group is also the group found to have the thickest interlayer in SEM. Based on these data, it can be concluded that the thick interlayer identified in SEM in the indirect bonding groups is not a weak zone. The score 5 recorded for these teeth reveals that the adhesive has neither efficiently bonded to the enamel surface, nor adhered to the enamel surface at all. However, we think that this has resulted from the fact that the tape surface of the composite resin base has weakened the bond strength with the adhesive primer due to its smooth surface structure. In the shear test results that we have obtained, lower values were recorded in the group TT compared to the IT group, which also supports our opinion. We think that this problem can be solved by using a tape with a rough surface for isolation purposes, thus further increasing the bonding values in the groups in which tape is used. Since the failure is of cohesive nature in all the other teeth, it is seen that there is no difference between the techniques in terms of the ease of cleaning of the composite residues remaining after debonding, either.

Conclusion

Because of the air bubbles in Sondhi adhesive groups, it is recommended to use Transbond XT as the adhesive system. However, in cases where light-cured adhesive systems cannot be used, Sondhi adhesive can be used on the condition that tape is preferred as the isolation method.

Author Contributions

B.K. and C.D. planned the study design. B.K. prepared the samples and performed the laboratuary tests. C.D. evaluated the results. B.K. wrote the text and C.D. made the necessary corrections.

Conflict of Interest

Authors declare that they have no conflict of interest.

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