



ORIGINAL RESEARCH PAPER

Dental Science

IN VITRO STUDY COMPARING SHEAR BOND STRENGTH OF BRACKETS BONDED WITH RESTORATIVE AND ORTHODONTIC RESINS.

KEY WORDS:

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ABSTRACT
 There are various resin composites used in dentistry for the purpose of restoration as well as orthodontic resins. An improved light-activated resins have been introduced commercially for the improvement in the concerned procedures. The aim of this study was to assess and compare the shear bond strength of the two restorative systems tested and determine whether they could be used for orthodontic bracket bonding, as well as to compare their bond strength values with those obtained with an orthodontic adhesive system already established on the market. This randomized, comparative, observational, in-vitro study was conducted on 60 extracted human maxillary premolar teeth in the Department of Orthodontics and Dentofacial Orthopaedics, College of Dental Sciences and Hospital, Rau, Indore. The results showed that restorative composite presented statistically similar shear bond strength values, it is compatible with the orthodontic application of accessory bonding. Restorative composite tested showed shear bond strength values statistically compatible with the bond strength presented by an orthodontic adhesive system established on the market.

INTRODUCTION
 From the time 1960, the first studies on bonding techniques for bonding brackets to the tooth surface were conducted, innumerable scientific advancements have been made to improve the techniques and the material.¹The improvement in light-activated resins benefitted resins designed for both restorative dentistry and orthodontic bracket bonding.

Orthodontic adhesives have a basic formula similar to that of resin composites commonly used in clinical restorative procedures, they are more expensive and are commercially available only from suppliers dealing exclusively with orthodontic materials there composition is similar to that of resins designed for restorations, and because the latter are less costly, have greater variety and availability.

The choice of the Transbond™ XT orthodontic adhesive system for the comparison was based on the results of several studies confirming its effectiveness, and also on the fact that it is frequently used as a reference when other systems are evaluated.²⁻¹¹ It would therefore be possible to assess whether the restorative systems tested could be considered acceptable in terms of the minimum strength requirements for satisfactory orthodontic bonding.

The purpose of this study was to assess and compare the shear bond strength of the two restorative systems tested and determine whether they could be used for orthodontic bracket bonding, as well as to compare their bond strength values with those obtained with an orthodontic adhesive system already established on the market

MATERIALS AND METHODS
 The present randomized, comparative, observational, in-vitro study was conducted on 60 extracted human maxillary premolar teeth in the Department of Orthodontics and Dentofacial Orthopaedics, College of Dental Sciences and Hospital, Rau, Indore. The premolars were obtained from a group of patients who underwent therapeutic extractions, prior to orthodontic therapy. Only morphologically well-

defined teeth with no caries, fractures, structural defects, restorations or treatment with chemical agents were included in the study.

MATERIAL:
1. BRACKETS-
 Sixty new stainless steel upper premolar brackets – Gemini metal brackets 0.022 (0.56 mm) MBT, 3M Unitek with bondable bases were used. The area of the bracket was 10.62mm².

2. ETCHANT -
 Etchant gel 37% phosphoric acid, Prime Dental Product Pvt Ltd.

3. ADHESIVES-
 a. Conventional acid etchant- Transbond XT (3M Unitek light cure orthodontic adhesive).
 b. Self adhering flowable composite- Dyad™ Flow (Kerr Corporation)
 c. Flowable restorative composite – Filtek™ Z350XT (3M ESPE universal restorative system)

4. Universal Testing Machine

5. Bonding Accessories-
 a. Applicator brush. (proprietary microbrush)
 b. Bracket holding tweezer.
 c. Light Curing Adhesive Primer Transbond™ XT (3M Unitek)
 d. Chip blower.
 e. Explorer.
 f. Light curing unit SmartLite® PS (DENTSPLY)
 g. Polishing rubber cup and pumice powder.
 h. Straight Hand piece.

Sample Preparation And Distribution:
 The freshly extracted teeth were immediately washed and cleaned with Hydrogen peroxide to remove blood or any tissue debris, then dipped in undiluted Betadine solution for 3 min and then stored in an airtight black glass container

containing 0.1% wt/vol thymol solution (thymol crystals in distilled water) to prevent bacterial contamination and dehydration. Later they were washed with distilled water and dried using chip syringe. The teeth were randomly divided into 3 groups of 20 teeth each, corresponding to three light cure bonding adhesives used for the study. The teeth were mounted on a cold cure acrylic block of dimension greater than 10mm x 10mm so that the block could be held properly in the Universal Tensile Testing Machine and the three groups were allotted individual colour code (Table.No- 1).

Table.no-1: Orthodontic Adhesive Used In The Study

Groups	Color Coding	Etchant	Adhesive Used For Bonding	Sample Size
Group I	Red	37% phosphoric acid, Prime Dental Product Pvt Ltd.	Transbond XT (Conventional Orthodontic Resin)	20
Group II	Green	Self Etching	DYAD FLOW (Self Adhering flowable Composite)	20
Group III	Blue	37% phosphoric acid, Prime Dental Product Pvt Ltd.	Filtek™ Z350 (Flowable Restorative Composite)	20

METHODS

Bonding Procedure:

The brackets were bonded to teeth according to following protocols:

Group I: CONTROL GROUP (TRANSBOND XT PRIMER & TRANSBOND XT ADHESIVE PASTE):

The polished and dried buccal surface of each tooth was etched with 37% phosphoric acid for 15 seconds. The etched surface was rinsed or washed thoroughly with distilled water and dried using chip blower. The surface was checked for a uniform white frosted appearance. A vertical line is drawn passing through the long axis of the tooth and a horizontal line that divides the tooth into two equal portions. The point of intersection of the two lines is taken as the midpoint "A". A thin coat of conventional primer (Transbond XT Primer) supplied by the manufacturer was applied on each dried surface with a brush in a single stroke and air was blown gently to remove excess primer.

A thin layer of adhesive Transbond™ XT was then applied to the metal bracket base mesh. The metal brackets, with the help of a bracket holding tweezer, were pressed gently for bonding near the centre of the facial surface of the teeth to ensure uniformity in the bracket seating. Subsequently, the excess adhesive was removed from the margins of the bracket with the help of an explorer/scaler. The brackets to be bonded were light cured for 10 seconds on each side of the brackets (i.e. mesial and distal) by exposing it to a light from the light curing unit.

GROUP II: SELF ADHERING FLOWABLE COMPOSITE (DYAD™ FLOW):

On the polished and dried buccal surface of each tooth a 0.5mm thick layer of Dyad Flow composite was applied on to the enamel surface and rubbed for 15-20 s with the proprietary microbrush. A thin layer of adhesive was then applied to the metal bracket base mesh. The metal brackets, with the help of a bracket holding tweezer, were pressed gently for bonding at midpoint "A" to ensure uniformity in the bracket seating. Subsequently, the excess adhesive was removed from the margins of the bracket with the help of an explorer/scaler. The brackets to be bonded were light cured for 10 seconds on each side of the brackets (i.e., mesial and

distal) by exposing it to a light from the light curing unit.

GROUP III: FLOWABLE RESTORATIVE COMPOSITE (FILTEK™ Z350XT):

The polished and dried buccal surface of each tooth was etched with 37% phosphoric acid for 15 seconds. The etched surface was rinsed or washed thoroughly with distilled water and dried using chip blower. The surface was checked for a uniform white frosted appearance. A vertical line is drawn passing through the long axis of the tooth and a horizontal line that divides the tooth into two equal portions. The point of intersection of the two lines is taken as the midpoint "A". A thin coat of Conventional primer (Transbond XT Primer) supplied by the manufacturer was applied on each dried surface with a brush in a single stroke and air was blown gently to remove excess primer. The primer was then light cured for 10 seconds.

The buccal surface of the teeth are polished and dried. Flowable restorative composite paste was applied to the bracket base, and the bracket was positioned on the etched and primed buccal surface with the help of bracket holding tweezer and was pressed gently for bonding at midpoint "A" to ensure uniformity in the bracket seating. Subsequently, the excess adhesive was removed from the margins of the bracket with the help of an explorer. The brackets to be bonded were light cured for 10 seconds on each side of the brackets (i.e. mesial and distal) by exposing it to a light from the light curing unit.

Evaluation Of Bond Strength:

The bonded samples were then stored in distilled water at room temperature in sealed containers in a beaker for 6 weeks before debonding. Shear bond strength was tested with a UNIVERSAL TESTING MACHINE, in the Material & Metallurgy wing of the Kailtech Test & Research Centre Pvt. Ltd, Indore and was evaluated according to the following procedure for all samples. The machine has two vertically placed jaws.

- The acrylic block with the tooth was placed in the lower jaw (Fixed head).
- A custom made debonding apparatus was fitted to the upper jaw of the machine (Movable head).

A force was applied to each bracket producing a shear force at the bracket-tooth interface at a crosshead speed of 1mm/min.

The Universal testing Machine unit was attached to an electronic console that displayed the debonding forces acting on the bracket tooth interface. Thus, the exact force at which the bracket debonded was noted from the console. This force was expressed in Mega Pascal's (Mpa).

$$\text{Force in Newton}$$

$$\text{Bond strength MPa} = \frac{\text{Force in Newton}}{\text{Surface area of bracket in mm}^2}$$

Evaluation Of Adhesive Remnant Index (ARI):

Immediately following debonding, specimens were then examined under magnification glass for allocation of Adhesive Remnant Index (ARI) score by Årtun and Bergland¹⁸, 1984 was used.

0. indicates no adhesive residue on the tooth in the bonding area,
1. less than 1/2 of adhesive residue remaining on the tooth in the bonding area,
2. more than 1/2 of adhesive remaining on the tooth in the bonding area,
3. all the adhesive remaining on the tooth in the bonding area.

RESULT

A. SHEAR BOND STRENGTH

- **Comparison of Shear Bond Strength (SBS) Between**

Same Groups: (Table.No-3, Graph.No-1)

SBS in group I:

The mean SBS with bonding 14.085 ± 0.32 MPa was compared to mean shear bond strength of Group II and Group III. This difference was statistically significant (p< 0.05) as confirmed by Paired 't' Test.

SBS in group II:

The mean SBS with bonding was observed to be 12.489 ± 0.716 MPa which was compared to mean of Group I and Group III. This difference was statistically significant (p< 0.05) as confirmed by Paired t Test.

SBS in group III:

The mean SBS with bonding was observed to be 10.104 ± 1.01 MPa which was compared to mean of Group I and Group II. This difference was statistically significant (p< 0.05) as confirmed by Paired t Test.

Comparison of SBS between different groups: (Table. No-4. Graph.No.1)

Bonding:

Group I had the highest initial SBS of 14.085 ± 0.32 MPa followed by Group II with 12.489 ± 0.716 MPa and Group III had the lowest mean bond strength of 10.104 ± 1.01 MPa. One way ANOVA test revealed statistically significant difference between 3 groups with bonding.

Difference in mean SBS between 3 groups: (Table.No-4)

Group I and Group III differ significantly. Group I has better shear bond strength than Group II. In Group I the mean was 14.085 ± 0.32, in Group III it was 10.104 ± 1.01 and in Group II it was 12.489 ± 0.716. The difference between the three groups was found to be statistically significant (P<0.05), showing that mean shear bond strength differ between the three groups as revealed by the 'ONEWAY ANOVA' test.

To find out the pair wise comparison the 'Post hoc Tukey' was applied. There was statistically significant difference seen in all of the pairs (p<0.05), showing that mean shear bond strength significantly higher in Group I and low in Group III as revealed by Post hoc Tukey test.

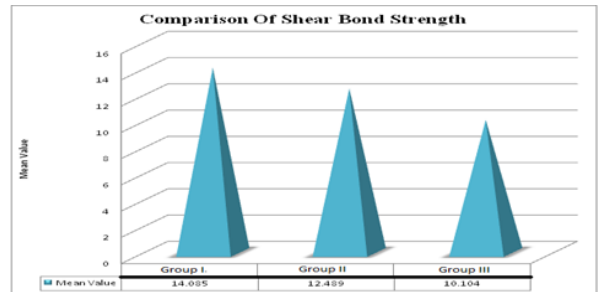
Table.no-2: Shear Bond Strength Of Various Groups

	CONTROL (GROUP I)		GROUP II		GROUP III	
TOOTH NO	SHEAR BOND STRENGTH	TOOTH NO	SHEAR BOND STRENGTH	TOOTH NO.	SHEAR BOND STRENGTH	
E0265	14.32	E0285	13.86	E0275	9.05	
E0266	14.14	E0286	11.32	E0276	8.58	
E0267	13.90	E0287	12.25	E0277	8.67	
E0268	14.51	E0288	11.80	E0278	9.05	
E0269	14.05	E0289	12.74	E0279	9.92	
E0270	13.67	E0290	12.00	E0280	10.35	
E0271	13.60	E0291	12.47	E0281	10.27	
E0272	14.12	E0292	12.94	E0282	10.55	
E0273	14.55	E0293	13.20	E0283	10.84	
E0274	14.49	E0294	13.11	E0284	10.93	
E0299	13.85	E0319	11.31	E0309	9.05	
E0300	14.14	E0320	11.19	E0310	9.39	
E0301	13.74	E0321	12.30	E0311	10.27	
E0302	13.96	E0322	13.19	E0312	10.56	
E0303	14.26	E0323	13.10	E0313	11.30	
E0304	14.28	E0324	12.87	E0314	11.51	
E0305	14.20	E0325	12.30	E0315	9.25	
E0306	14.47	E0326	12.16	E0316	12.16	
E0307	14.05	E0327	12.65	E0317	10.93	
E0308	13.40	E0328	13.02	E0318	9.44	

Table. no-3: Comparison Of Mean Shear Bond Strength Between Various Groups

Groups	Mean ± SD	ANOVA	
		F Value	P Value
Group I	14.085 ± 0.32	146.72	0.000*
Group II	12.489 ± 0.716		
Group III	10.104 ± 1.01		

One-way ANOVA applied. P value = 0.000, * Significant



Graph. no-1: Comparison Of Mean Shear Bond Strength Between Various Groups

Table. No-4: Intragroup Comparison Using Post Hoc Tukey Test

Pair	Mean Difference	Significance	
		't' Value	P Value
Group III to Group I	3.981	17.02	0.000*
Group II to Group I	1.596	6.82	0.000*
Group III to Group II	2.386	10.20	0.000*

* Significant

B. ADHESIVE REMNANT INDEX SCORE

Comparison of Adhesive Remnant Index (ARI) between same groups: (Table.No- 6, Graph.No-2)

ARI in Group I:

The mean ARI score after de-bonding was 1.850 ± 0.93 it was compared to mean adhesive remnant index score of Group II and Group III. This difference was statistically insignificant when compared to Group III where as when compared to Group II the difference was statistically significant, confirmed by Paired 't' Test.

ARI in Group II:

The mean ARI score was observed to be 0.800 ± 1.00 which was compared to mean of Group I and Group III. This difference was statistically significant (p< 0.05) as confirmed by Paired 't' Test.

ARI in Group III:

The mean ARI score was observed to be 1.700 ± 1.08 which was compared to mean of Group I and Group II. This difference was statistically significant (p< 0.05) when compared to group II and statistically insignificant when compared to group III as confirmed by Paired 't' Test.

Comparison Of ARI Between Different Groups: (Table. No-7)

Bonding:

Group I had the highest ARI score of 1.850 ± 0.93 followed by Group III with 1.700 ± 1.08 and Group II had the lowest mean adhesive remnant score of 1.700 ± 1.08. One way ANOVA test revealed statistically significant difference between 3 groups with bonding.

Difference in mean ARI score between 3 groups: (Table.No-7)

Group I and Group III differ non-significantly. Group I has greater adhesive remnants than Group II. In Group I the mean

was 1.850 ± 0.93, in Group III it was 1.700 ± 1.08 and in Group II it was 0.800 ± 1.00. The difference between the three groups was found to be statistically significant (p<0.05), showing that mean adhesive remnant index differ between the three groups as revealed by the ONEWAY ANOVA test.

To find out the pair wise comparison the Post hoc Tukey was applied. There was statistically significant difference seen in Group II- Group I and Group II- Group III pairs (p<0.05), but not significant in Group III -Group I (p>.05) showing that mean adhesive remnant score is significantly lower in Group II as revealed by Post hoc Tukey test.

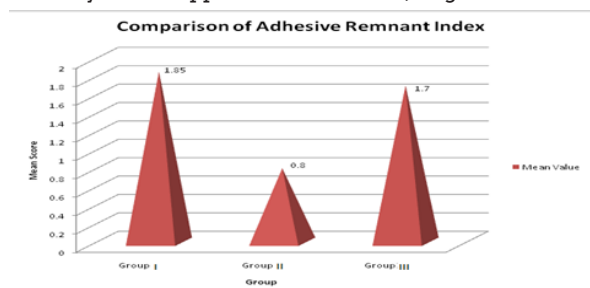
Table. No-5: Adhesive Remnant Score Of Various Group

	Control (group I)		Group II		Group III
Tooth No	Shear Bond Strength	Tooth No	Shear Bond Strength	Tooth No.	Shear Bond Strength
E0265	3	E0285	0	E0275	2
E0266	3	E0286	3	E0276	1
E0267	3	E0287	2	E0277	0
E0268	0	E0288	1	E0278	3
E0269	2	E0289	0	E0279	1
E0270	3	E0290	0	E0280	0
E0271	3	E0291	0	E0281	3
E0272	1	E0292	0	E0282	2
E0273	2	E0293	0	E0283	3
E0274	1	E0294	3	E0284	0
E0299	1	E0319	0	E0309	2
E0300	3	E0320	0	E0310	1
E0301	1	E0321	1	E0311	2
E0302	2	E0322	0	E0312	2
E0303	1	E0323	1	E0313	3
E0304	2	E0324	1	E0314	2
E0305	1	E0325	0	E0315	3
E0306	2	E0326	1	E0316	2
E0307	1	E0327	2	E0317	0
E0308	2	E0328	1	E0318	2

Table. No-6: Comparison Of Mean Adhesive Remnant Score Between Various Groups

Groups	Mean ± SD	ANOVA	
		F Value	P Value
Group I	1.850 ± 0.93	6.34	0.003*
Group II	0.800 ± 1.00		
Group III	1.700 ± 1.08		

One-way ANOVA applied. P value = 0.000, * Significant



Graph. no-2: Comparison Of Mean Adhesive Remnant Between Various Groups

Table. no-7: Intragroup Comparison Using Post Hoc Tukey Test

Pair	Mean Difference	Significance	
		t' Value	P Value
Group III to Group I	0.150	0.47	0.885
Group II to Group I	1.050	3.29	0.005*
Group III to Group II	0.900	2.82	0.018*

*Significant

Stastical Plan

The obtained data was subjected to following statistical analysis. Descriptive statistics including the mean, standard deviation (SD), minimum and maximum values were calculated for each of the 3 experimental groups tested.

1. **One Way Analysis Of Variance (ANOVA)** was used to determine whether significant differences existed between the various groups of the bond strength values calculated.

2. **Post hoc Tukey** was used to find out the pair wise comparison of groups.

Significance for all statistical tests was predetermined at p < 0.05.

Present study aimed to assess and compare the shear bond strength in three different groups and their Adhesive Remnant Index Score (ARI) following removal of orthodontic brackets.

DISCUSSION

According to Reynolds¹², the minimum shear bond strength values of orthodontic appliances range between 5.8 MPa and 7.8 MPa. The results of the present study confirmed this expectation for both the resins assessed, thus confirming that they can be safely indicated for bonding orthodontic brackets.

On comparing the shear bond strength of both the group, it was found that the behaviour of the groups was statistically similar and that the values obtained were always above the minimum requirements.

Since size and form differences in the bracket base may affect the shear bond strength values obtained,¹¹ studies using the same brand and type of brackets was done which was stainless steel metal premolar brackets- Gemini metal brackets .022(0,56 mm) MBT Rx

The standard deviations found in this study varied between 2.67 and 3.18, suggesting the existence of a balance between the groups, showing greater reliability in the standardization of the methods used. This study showed adhesive systems with mean bond strength values higher than those needed for good bonding, although the difference was not statistically significant.

CONCLUSION

Based on the method adopted in this study and in accordance with the results obtained, it was concluded that:

Restorative composite presented statistically similar shear bond strength values, it is compatible with the orthodontic application of accessory bonding.

Restorative composite tested showed shear bond strength values statistically compatible with the bond strength presented by an orthodontic adhesive system established on the market.

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