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AN IN VITRO SHEAR BOND STRENGTH STUDY TO EVALUATE THE EFFICACY OF ADHESION BOOSTER ON COMPROMISED BONDING SITUATION

DR. PRAVEEN.S	Associate Professor Department Of Orthodontics Government Dental College Kozhikode
DR. LATHEEF V.P	Associate Professor Department Of Orthodontics Government Dental College Kozhikode
DR. PRAVEEN.K	Assistant Professor Department Of Orthodontics Government Dental College Kozhikode

ABSTRACT The purpose of this study was to evaluate the effects of adhesion boosters, Enhance (Reliance, Itasca, Ill) on the shear bond strength on normal and wet enamel surfaces. 80 human premolar teeth that were extracted were used in this present study. 20 samples were bonded normally 20 bonded using adhesion boosters. 20 samples were bonded without adhesion boosters on wet enamel surface and 20 teeth were bonded on wet enamel surface with the use of adhesion booster. The samples were tested for the maximum load using an InstronTM machine running at a crosshead speed of 1mm/minute and the debonding strength were calculated. Results show that the normal bonding to enamel surface gave a bond strength of 16.79 MPa. The samples when bonded normally but using adhesion boosters did enhance the bond strength value to 22.88 MPa. Bonding to wet enamel surface without the use of adhesion booster resulted in decrease in bond strength 2.07 MPa. And when bonding was done to wet enamel surface with the use of adhesion booster it was found to be 5.55 MPa. It was concluded that Enhance the adhesion booster manufactured by Reliance increased the shear bond strength on wet enamel surface making it possible to be used effectively in such clinical situations.

KEYWORDS : Adhesion boosters, bonding, wet enamel surface, significant, orthodontics

INTRODUCTION

Trends in orthodontics as in any other sphere of human activity is to try and simplify technical procedures so that objectives can be achieved with minimum effort.

Bonding various resins to enamel developed in all fields of Dentistry including orthodontics, pioneering work of Buonocore[1] and George V Newman[2,3] for bonding direct orthodontic attachments to enamel gave new thought to researchers. Since then there was no looking back and the science of bonding became major sub specialty in orthodontics.

Enhanced adhesion between the surface and the adhesive is mandatory in compromised surface for efficient orthodontic treatment, Rapid strides in technology and material science coupled with endless search for the ultimate adhesive that provide adequate strength, we are behind for best bond strength in any compromised situation.

Adhesion Booster, a tooth primer containing HEMA [Hydroxyl ethyl methacrylate][3,4] with both hydrophilic and hydrophobic functional units is advocated by Bowen et al to increase the bond strength of composite resin to tooth surface has been available in market for many years. ENHANCE[Reliance Orthodontics] and All-Bond 3(Bisco, Schaumburg, USA) are the commercially available boosters claiming better bonding to wet enamel, dentine, metal, composite and porcelain surfaces.

AIMS AND OBJECTIVES

This in vitro investigation aim at assessing the efficiency of adhesion boosters in enhancing shear bond strength of chemical cure adhesive on normal and wet enamel surface.

OBJECTIVES

1. To estimate and compare the shear bond strength of new brackets on normal enamel surface
A. Chemical cure composite without use of adhesion booster
B. Chemical cure composite along with the application of adhesion booster
2. To estimate and compare the shear bond strength of new brackets on moistened enamel using
A. Chemical cure without the use of adhesion booster
B. Chemical cure with the use of adhesion booster

MATERIALS AND METHODS

80 human premolar teeth that was extracted as a part of orthodontic treatment were used. The samples were collected and stored in room temperature in a plastic container. The fluid media was changed at periodic intervals in order to prevent the growth of bacteria and subsequent contamination of the sample. Of the 80, 40 were upper and rest lower premolars. All samples were healthy without any carious lesions, with no evidence of surface defects or any developmental morphological aberrations. The teeth were divided into 4 groups of 20 each.

Eighty new stainless steel contoured Begg [Series 256-500] brackets with bondable base was used for the purpose. All the brackets were of uniform size. The brackets used for the purpose were manufactured by TP Orthodontics Inc. La Porte Indiana. The base of the bracket measured approximately 3.42mm in length and 3.31mm in width. Self-curing composite resin [Rely-a-bond™, no mix fluoride releasing orthodontic adhesive, Reliance Orthodontic Products, Inc., Illinois, Itasca] Adhesion booster [Enhance™Chemical cure adhesion booster system by Reliance Orthodontic Products, Inc., Illinois, Itasca]. The samples were divided into 4 groups. All samples were embedded in a cylindrical acrylic block of (PMMA) so that only the coronal portion of the specimen was exposed. The crown were oriented along the long axis of the block and were stored in distilled water at room temperature in a closed airtight container. The samples in each group were randomly selected from the container.

Facial surface of each tooth was cleaned with non-fluoride oil free pumice paste. The tooth was rinsed with water and dried with oil free air spray. The enamel surface was etched with 37 percentage liquid phosphoric acid [Reliance, Itasca] for thirty seconds and rinsed with water for 30 seconds. For Group one enamel surface was dried with an air syringe. For Group 2 excess water on the etched enamel was removed was removed with a brief burst of air and some moisture was allowed to remain on the enamel surface without desiccation.

Group 1 normal enamel surface bonded with new bracket the samples were further divided into two subgroups **G-11** and **G-12**

G-11 the samples in the group were bonded using chemical cure composite alone. The surface to be bonded were coated with the

bonding primer supplied in the kit. The mesh bases of the bracket were also coated with the primer. The adhesive plate was then applied onto the bracket base and bonding carried out as usual.

G-12 after the required conditioning of the tooth surface as described earlier were made, the samples were bonded with the presence of adhesion booster. In a mixing well a drop of each Part-A and Part- B Enhance™ Adhesion Booster was dispensed. A brush was used to mix the drops for 5 seconds and then four strokes were applied onto the enamel surface of be bonded. After 20 seconds the surface was dried with oil free air. Reapplication of the second coat was considered if the earlier treatment did not result in a shiny surface. The Rely A Bond primer was applied onto the bonding surface and the bracket base and the adhesion paste were subsequently applied to the mesh base of the bracket and bonded in place.

Group 2 wet enamel surface bonded with new brackets

The samples in this group were subdivided into two sub groups **G-21** and **G-22**

G-21 Samples in this group were bonded using chemical cure composite alone. Over the wet enamel surface to be bonded a thin layer of primer was applied and also over the bracket base. The adhesive paste was applied onto the bracket base and bonded

G-22 Samples in this group were bonded with the use of Adhesion Booster. After the Part A and Part B Enhance™ were mixed together a thin layer [4-5 strokes with a brush] was applied onto the etched enamel surface with moisture. Bonding was carried out using Rely-A-Bond primer and paste after 20 seconds.

RESULTS

SPECIMEN SUB GROUP G-11 [TABLE-1]

Shear bond strength of normal samples bonded without adhesion booster in Newton's and Mpa

SP.NO.	MAXIMUM LOAD	BREAK LOAD IN NEWTON	BREAKLOAD IN MPa
1	109.26	109.26	9.75
2	201.25	200.25	17.87
3	223.07	218.71	19.52
4	114.07	111.54	9.95
5	300.18	300.00	26.78
6	153.00	147.25	13.14
7	221.59	221.51	19.77
8	239.17	235.90	21.06
9	289.50	287.42	25.66
10	155.00	151.32	13.51
11	151.68	150.82	13.46
12	90.85	90.85	8.11
13	214.35	204.62	18.24
14	304.65	300.00	26.78
15	308.31	300.00	26.78
16	151.01	150.01	13.40
17	164.43	163.35	14.58
18	130.08	129.23	11.53
19	172.00	171.63	15.32
20	121.20	120.36	10.74
Mean	**233.12**	**188.20**	**16.79**
Std. dvtn	**67.10**	**68.25**	**6.09**
Maximum	**308.31**	**300.00**	**26.78**
Minimum	**90.85**	**90.85**	**8.11**
Range	**217.46**	**209.15**	**18.67**

SPECIMEN SUB GROUP G-12 [TABLE-2]

Shear bond strength of normal samples bonded with adhesion booster in Newton's and Mpa

SP.NO.	MAXIMUM LOAD	BREAK LOAD IN NEWTON	BREAKLOAD IN MPa
1	227.29	224.29	20.02
2	174.22	170.75	15.24
3	206.24	204.26	18.23
4	240.22	239.53	21.38
5	239.51	217.57	19.42
6	322.39	321.46	28.70
7	283.43	276.00	24.64
8	89.31	85.06	7.39
9	255.43	248.57	22.19
10	350.18	350.00	31.25
11	350.14	350.00	31.25
12	200.64	200.64	17.91
13	242.54	207.45	18.52
14	152.68	125.21	11.17
15	341.12	328.71	29.34
16	350.46	350.00	31.24
17	310.46	307.33	27.44
18	245.22	234.45	20.93
19	223.44	214.22	19.12
20	234.66	227.12	20.17
Mean	**251.981**	**239.631**	**22.88**
Std. dvtn	**70.91**	**73.92**	**6.62**
Maximum	**350.46**	**350.00**	**31.25**
Minimum	**89.31**	**85.06**	**7.39**
Range	**261.15**	**264.94**	**23.86**

SPECIMEN SUB GROUP G-21 [TABLE-3]

Shear bond strength of normal samples bonded on wet enamel surface without adhesion booster in Newton's and Mpa

SP.NO.	MAXIMUM LOAD	BREAK LOAD IN NEWTON	BREAKLOAD IN MPa
1	31.23	28.34	2.53
2	40.14	24.48	2.18
3	39.67	38.62	3.44
4	36.90	30.35	2.70
5	28.31	28.11	2.50
6	18.78	16.44	1.46
7	15.56	15.31	1.36
8	27.48	21.64	1.93
9	40.14	32.93	2.94
10	69.90	52.17	4.65
11	4.87	4.0	0.35
12	20.70	16.34	1.45
13	18.20	15.32	1.36
14	20.00	19.45	1.73
15	13.52	17.24	1.53
16	19.26	16.67	1.48
17	33.59	28.56	2.55
18	27.79	23.16	2.06
19	16.56	15.76	1.40
20	24.67	21.67	1.93
Mean	**28.28**	**23.32**	**2.07**
Std. dvtn	**13.98**	**10.36**	**0.92**
Maximum	**69.90**	**52.17**	**4.65**
Minimum	**4.87**	**4.0**	**0.35**
Range	**65.03**	**48.17**	**4.3**

SPECIMEN SUB GROUP G-22 [TABLE-4]

Shear bond strength of normal samples bonded on wet enamel surface with adhesion booster in Newton's and Mpa

SP.NO.	MAXIMUM LOAD	BREAK LOAD IN NEWTON	BREAKLOAD IN MPa
1	60.45	58.93	5.26
2	100.42	93.25	8.32
3	54.78	50.67	4.32
4	87.34	83.45	7.45
5	62.14	57.87	5.16
6	83.34	56.34	5.03
7	51.09	45.67	4.07
8	57.46	34.07	3.04
9	58.53	55.28	4.93
10	50.37	46.09	4.11
11	60.17	52.68	4.70
12	43.48	40.79	3.64
13	111.50	108.25	9.66
14	62.68	60.34	5.38
15	140.95	135.67	12.11
16	65.14	64.87	5.79
17	48.67	45.03	4.02
18	65.20	55.25	4.93
19	109.78	89.52	7.99
20	**67.63**	**65.43**	**5.84**
Mean	**74.23**	**64.97**	**5.55**
Std.dvt	**25.57**	**25.14**	**2.25**
Maximum	**140.95**	**135.67**	**12.11**
Minimum	**43.48**	**40.75**	**3.64**
Range	**97.47**	**94.92**	**8.47**

DISCUSSION

Current research trends that aimed to address the problem of clinically ineffective bond strength to compromised tooth surfaces and clinical situations have resulted in the emergence of a new class of materials that warrant a separate classification among the material used for orthodontic bonding-Adhesion promoters. Adhesion boosters, a tooth based surface primer advocated by Bowen et al to increase the bond strength of composite resin to tooth surface have been available in dental market for many years. Different adhesion promoters are available for use with specific substrate.

Enhance ™ and Enhance LC are introductions into this arena. The manufacturer claims superior bonding to atypical tooth surfaces including wet and fluorosed enamel surfaces, stainless steel surfaces, acrylic surfaces, porcelain, and amalgam that under normal circumstances would produce a clinically unacceptable bond. Since their introduction many investigators have studied the effect of adhesion promoters, yet the result were inconclusive. Having understood the need for compromised surface bonding and the materials available that claim to perform well on such surfaces, it was decided to take up this test to study the efficacy of adhesion boosters on normal and wet enamel surfaces.

The purpose of this study was to determine whether the use of an NTG-GMA based adhesion booster Enhance™ in conjunction with the corresponding composite would result in increased bond strength.

Bond strength observed between the different resin-adhesion booster combinations within each sample was recorded after 48hrs of bonding. Ching et al observed that the bond strength on the first day was greater than that at any time from the second day to the 32nd week, and the difference among successive time intervals from the second day to the 32nd week were not statistically significant. After a relatively large initial loss, bond strength was stabilized. A Shimadzu universal test machine was used for evaluating the shear bond strength of individual samples. Each bond specimens was meticulously stabilized with suitable clamps to the machine base. The blade directed against the base of the bracket or the point of attachment of the bracket to the teeth. The crosshead speed of the device was set at 1mm/minute. The break load and the maximum load were recorded. The shear bond strength to debond each bracket was recorded electronically in Newton's and converted to Megapascals.[MPa]. The data obtained was analysed statistically. The following interpretations were derived from the analysis. Coefficient of variance showed that ANOVA couldn't be applied to these samples due to very high variability of break load obtained. A median test and a Kruskal Wallis ANOVA test were performed to know the significance of these observations. This showed that there was significant difference between the group at 1% level. The mean shear bond strength of sample G-11 new brackets on normal enamel surface without the use of adhesion boosters was 16.79 MPa with standard deviation of 77.24, which is comparable to bond strength values obtained in a similar study by Chung[7] et al [16.8 MPa], less than the value by Pramod.k.Sinha [6] [19.4MPa]. 25-75% of the breakload observations fell between 13-20 MPa and a median value of around 15 MPa. The range was 18.67 MPa. This high range could be due to variation in enamel structure that varies from specimen to specimen, moreover contours of the selected premolars could be different preventing even thickness of the adhesive under the brackets. Such high values may not be reached intraorally as obtained in an in-vitro study for the fact that clinically we face more compromised situation and contaminations and patient variables.

Sample G-12 [New brackets/ normal enamel surface with the use of adhesion booster] gave a mean shear bond strength value of 22.88 MPa which, when compared to other studies was a much higher value. A similar study done by Chung[7] et al 13.6 MPa. 25-75% fell between 18-27 MPa. This range obtained here was higher than G-11 sample, this could decrease the credibility of the mean higher break load recorded for this group showing that application of adhesion booster failed to improve the shear bond strengths consistently in all samples. As long as the manufacturer keeps the composition and the mode of action of these Boosters a trade secret valid explanations behind such results cannot be derived. Statistically with a p value of 0.14 [$p<0.05$] and the higher median obtained for this group it could be concluded that application of adhesion booster resulted in increase in shear bond strength values. Chemical components of the adhesion booster being such a low viscosity could completely penetrate the microporosities of the enamel surface with less polymerization shrinkage.

Reynolds showed that the average amount of force applied through the mastication on anterior bracket is 5MPa, whereas on posterior bracket is in a range of 20MPa. Accordingly to uniform results throughout the mouth the adhesive should withstand forces in a range of 20 MPa. Gange has suggested that the majority of the adhesive available today when correctly integrated with proper tooth preparation technique will provide strength in the 20 MPa range, without the risk of significant damage to the enamel upon debonding.

Adequate isolation and dry environment needed for bonding may not be clinically attainable in all condition. Orthodontist face many situations where direct bonding need to be done on to the moist surfaces, like enamel close to gingiva which gets contaminated with crevicular fluid. Young individual who salivate profusely or after a surgical exposure. Bond strength achieved in such wet atmosphere is always lower than the clinically desirable. Most of the present composites available are hydrophobic chemicals, which fail to set adequately under wet conditions.

This is evidenced by the sample G-21, bonding done on wet atmosphere with new brackets. Here excess moisture after etching was not removed and the Rely-A-bond no mix adhesive placed over the wet surface. The mean shear bond strength achieved was 2.07 MPa and this value was mostly consistent with a very low range [4.3 MPa], which definitely is much lower than the critical range of 5-8 MPa as suggested by Kusy et al. this demonstrates that Rely A Bond alone fail to achieve adequate bond strength on wet environment. Enhance ™ that claimed to provide adequate strength on wet

surfaces, was put to test on samples G-22. Bonding was done to wet enamel surface with the use of adhesion booster. Mean shear bond strength of 5.55 MPa was achieved. His value surely falls into the minimally clinically desirable range if not as suggested by Kusy. It is difficult to determine whether the in vitro shear bond strength obtained adequately correlates with the bond strength needed clinically to withstand the intraoral forces. According to Reynolds values from 5 to 8 MPa would appear reasonable. This value when analysed statistically was found to be significantly greater than G-21 sample group. p value of 3.94 [$p<0.05$] was derived when calculating demonstrating a very significant improvement in the shear bond strength value. 25-75% of the observations fell in the range of 5-7 MPa.

SUMMARY AND CONCLUSION

This in vitro study was conducted to assess the effect of adhesion booster on the shear bond strength of orthodontic brackets on normal and compromised enamel surfaces.

Results obtained when analysed helped us conclude

1. Use of adhesion booster while bonding resulted in improvement of shear bond strength on normal enamel surface significantly
2. Adhesive tested [rely a bond] did not provide clinically adequate bond strength , when used alone in wet surfaces
3. When adhesive was used along with adhesion booster on wet enamel surfaces there occurred a significant improvement of shear bond strength value that was clinically acceptable.

This finding help us conclude that use off adhesion booster enhances the shear bond strength particularly on certain compromised surfaces like moisture contamination and hence could be used as an adjunct during bonding.

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Conflict of interest

NIL

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