ORIGINAL RESEARCH

A Comparative Evaluation of Two Adhesion Promoters on Bonding of Orthodontic Brackets to Fluorosed Enamel: An *in vivo* Study

[1]Seema Grover, [2]Maninder Singh Sidhu, [3]Mona Prabhakar, [4]Ashish Dabas, [5]Vikas Malik, [6]Puneet Yadav
[7]Rohan Diwakar, [8]Sandeep Kumar

ABSTRACT

Bonding on fluorosed enamel is a challenge for orthodontists due to frequent bond failures at compromised enamel interface.

Objectives: Aims of this *in vivo* study were to evaluate and compare effects of two adhesion promoters, Enhance LC and All-Bond 3, on bonding to fluorosed enamel in orthodontic patients.

Materials and methods: Clinical study included 18 patients with age group range of 13 to 25 years. Two bond promoters Enhance LC (Reliance, Itasca, IL, USA) and All-Bond 3 (Bisco, Schaumburg, IL, USA) were used to test bond failure rate in all patients using split mouth technique. Enhance LC and All-Bond 3 were used randomly in upper right and lower left quadrants or *vice versa* to remove bias. Total 264 severely fluorosed teeth were bonded and monitored for 9 months. Bond failures were recorded in log book. Chi-square test was done to compare number of bracket failures between two groups and number of patients experiencing at least one bond failure.

Results: Study showed significant difference between bond failure rate of two adhesion promotors (P–0.039%). Bond failure rate was 3.03% in Enhance LC group and 9.1% in All-Bond 3 group. Number of patients experiencing bond failure rate were also statistically significant (P–0.034).

Conclusion: Study showed clinically acceptable bond failure rate with Enhance LC compared to All-Bond 3 group. Hence, use of Bond promoters is suggested to be mandatory before bonding in patients with fluorosed enamel.

Keywords: Bond failure, Bonding, Bond promoters, Fluorosed enamel.

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[1-3]Professor, [4,5]Reader, [6-8]Senior Lecturer

[1-8]Department of Orthodontics, Sri Govind Tricentenary Dental College, Gurgaon, Haryana, India

Corresponding Author: Seema Grover, Professor Department of Orthodontics, Sri Govind Tricentenary Dental College, Gurgaon, Haryana, India, e-mail: seemaortho@gmail.com

INTRODUCTION

Fluorosed enamel challenges orthodontists for bonding brackets due to frequent bond failures at compromised enamel interface. Enamel fluorosis demonstrates an outer hypomineralized and acid resistant layer, where it is difficult to attach bonds because a reliable etched enamel surface cannot be produced.[1] Fluorosis manifests itself as defects in the subsurface enamel ranging in color from white to brown or occurring as pits and irregular white opaque lines, striations or cloudy areas which further exacerbate the problem of bonding.[2]

Scanning electron microscopic studies have confirmed that difficulty in bonding is attributable to inability of fluorosed enamel to be effectively etched with 37% phosphoric acid,[3] which results in decreased amount of enamel irregularity, preventing effective bonding. Clean tooth surfaces have higher surface energy that is amenable to bonding,[4] but fluoride on the surface can lower the surface energy of the adherend, decreasing the ability of adhesive to spread. Hence, teeth with a higher concentration of fluoride are generally considered to be more resistant to acid etching and require a longer etching time. Bond strength in a group of mild to moderately fluorosed teeth demonstrated 40% reduction in bond strength compared to normal teeth.[5] Similarly, other previous studies have demonstrated lower shear bond strength between composite material and fluorosed enamel.[6-8]

In contrary to above studies, Ng'ang'a et al reported no significant difference in tensile bond strength between fluorotic and nonfluorotic teeth.[9] They found no significant differences between mean etch depth in the fluorotic and nonfluorotic teeth, but etch pattern was different. The variation in pattern was in agreement with the findings of other workers.[10-12] They highlighted the variation in structure that can occur in enamel not only from tooth to tooth or surface to surface, but also from site to site on a single tooth surface. Weerasinghe et al found that severity of fluorosis adversely affected the micro shear bond strength (SBS) of self etching bonding system to fluorosed enamel.[7] The above conflicting review can be due to different materials used and severity of fluorosis in different studies. Many investigators have recommended

extended enamel conditioning with phosphoric acid when bonding composite resin to fluorosed enamel to remove acid resistant hypomineralized surface layer and increase shear bond strength.[5,6] In addition to this, adhesion promoters have been introduced in orthodontics in last decade to enhance bond strength of the brackets and to save chairside time in fluorosed enamel cases.

Adhesion promoters are composed of hydroxyethylmethacrylate (HEMA), tetrahydrofuryl cyclohexane dimethacrylate and ethanol. The HEMA molecule contain two functional groups, one hydrophobic and other hydrophilic.[13] The incorporation of hydrophilic monomers to adhesive system facilitates the infiltration of resin into the etched enamel, reducing interfacial porosity and, therefore, adhesive defects, achieving greater bond strength after polymerization.[14] Enhance LC (Reliance, Itasca IL, USA) and All-Bond 2 (Bisco, Schaumburg, IL, USA), now replaced by All-Bond 3 and Ortho Solo (Ormco, orange, California, USA) are examples of available adhesion promoters.

Several *in vitro* and *in vivo* studies have been reported in literature to evaluate efficiency of adhesion promoters to increase bond strength. But no *in vivo* study has been performed till date to compare the effect of different adhesion promoters on bond failure rate in fluorosis patients.[15-19]

Hence, aim of this *in vivo* study was to evaluate and compare the effects of using two adhesion promoters, Enhance LC (Reliance, Itasca, IL, USA) and All-Bond 3 (Bisco, Schaumburg, IL, USA) on bond failure rate in fluorosed enamel patients.

The null hypothesis was that fluorosis did not increase the bond failure and none of two adhesion promoters decreased the bond failure rate in fluorosed enamel patients.

MATERIALS AND METHODS

The study was conducted on 18 patients with age group range from 13 to 25 years old, who reported for treatment to department of orthodontics in an institute representing fluorosed enamel. An informed consent was obtained from each patient who participated in the study. A total of 264 teeth with severe fluorosed enamel were bonded in both maxillary and mandibular arches with 132 teeth in each arch.

The fluorosed teeth were selected according to modified Thylstrap and Fejerskov Index (TFI) which is based on clinical changes in fluorosed teeth. Briefly in the TFI index, the enamel changes observed clinically on a single tooth are given scores ranging from 0 (no fluorosis) to 9 (lack of main part of enamel with respect to change in the anatomic appearance of the surface). In teeth assigned score 3, the surface shows merging and irregular cloudy areas of opacity, whereas in score 4, entire surface exhibits marked opacity or appear chalky white.

These patients underwent fixed orthodontics appliance therapy. An equal number of teeth on each side of arch, with a minimum of four teeth per quadrant were included.

A split mouth technique was used for applying Enhance LC (Reliance, Itasca, IL, USA) and All-Bond 3 (Bisco, Schaumburg, IL, USA) bond promoters, in all the patients. Enhance LC and All-Bond 3 (Bisco, Schaumburg, IL, USA) were used in upper right and lower left quadrants or *vice versa* randomly with equal division in all patients to remove bias.

Before bonding, the facial surfaces of teeth were cleaned with a mixture of water and pumice. As shown in previous study, conducted by Grover et al, the bonding of fluorosed teeth after pumicing showed less bond failures than nonfluorosed teeth.[20] Following this, the teeth were rinsed thoroughly with water and dried with oil and moisture free compressed air. Each tooth was etched with 37% phosphoric acid gel (Gel Etch®, 3M Unitek, Monrovia, California, USA) for 30 seconds, rinsed with water for 30 seconds, and dried until a characteristic frosty white etched area was observed.

Group 1 comprised patients where Enhance LC (Reliance, Itasca, IL, USA) was used as bond promoter in any two quadrants of all patients. Two or three layers of Enhance LC were applied on the etched fluorosed enamel and dried with compressed air according to manufacturer's instructions. Following that, a layer of Transbond XT primer (3M Unitek, Monrovia, California, USA) was applied on Enhance LC coated layer. After that Transbond XT (3M Unitek, Monrovia, California, USA) paste was applied to the bracket base and pressed firmly on to the tooth. Excessive adhesive was removed around the base of bracket and adhesive was light cured with an Ortholux XT lamp (3M Unitek), positioning the light guide on each interproximal side for 10 seconds.

In group 2, after etching the fluorosed enamel, two to three layers of All-Bond 3 were applied as bond promoter in remaining two quadrants of all patients. The surface was dried with compressed air to get shiny appearance. Immediately afterwards, the bracket was bonded in place with Transbond XT primer and paste. A check for occlusal interferences was made. All the patients of both groups had initial wire NiTi 0.014" in diameter (3M Unitek) followed by leveling NiTi wire of 0.016" in diameter (3M Unitek). All the wires were secured with elastomeric modules. Each patient was given follow-up instructions.

A bond failure was defined as any bracket that debonded after wire placement and occlusal check. The patients were followed up at 4 weeks interval for

consecutive 9 months. Each bracket was checked at each appointment for full or partial debond. Hygiene status was monitored at each visit. Patients with loose brackets were questioned as whether it occurred as a result of traumatic incident or chewing on hard candy. Bond failures were recorded in a log book for each patient for each quadrant over a 9-month period. The debonded brackets were recorded by patient's name and failure location. Debonded brackets were rebonded and removed from failure account.

Chi-square analysis was used to compare the number of bracket failures between Enhance LC and All-Bond 3 group. Also, the number of patients experiencing at least one bond failures were recorded.

RESULTS

A total of 264 teeth with fluoridated enamel were bonded in 18 patients. Enhance LC and All-Bond 3 were used as bond promoters in two groups having 132 teeth in each group to enhance bond strength and to reduce bond failures.

Table 1 denotes the total number of bond failures in both groups. In Enhance LC group, there were four failures (3.03%) and in All-Bond 3 group, there were 12 bond failures (9.1%). Therefore, significantly more bond failures were observed in All-Bond 3 group (p–0.039%) (Graph 1).

After 9 months of intraoral service with progression of arch wires from round nickel titanium to rectangular stainless steel, overall 16 bond failures (6.1%) occurred.

Table 2 represents the number of patients experiencing bond failure in the two groups. In Enhance LC group, 4 bond failures occurred in 3 patients. In All-Bond 3 group, 9 patients experienced 12 bond failures. Hence, statistically significant (p = 0.039) difference occurred between patients experiencing bond failures. Also, more bond failures were observed in maxilla compared to mandible and on right side as compared to left side. The bond failure location involved premolars and lateral incisors in maxilla and lateral incisors in mandible (Graph 2).

DISCUSSION

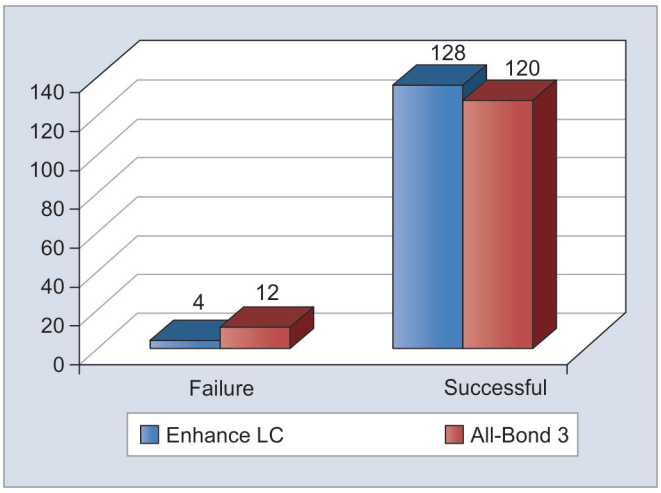
The null hypothesis that there would not be any difference between bond failure rate using Enhance LC or All-Bond 3 as bond promoters on fluorosed enamel was rejected. The results of the study suggest that use of an adhesion promoter is an alternative to micromechanical retention when bonding to compromised enamel surface in orthodontics.

Dental fluorosis is endemic in some part of the world and recent studies indicate a trend toward higher prevalence then previously reported. Thylstrap and Fejerskov Index has been found to be more sensitive than Dean's index particularly with regard to lower degrees of the condition.[21-23] The Gurgaon district of Haryana, India is a fluorosis prone area, so number of cases with dental fluorosis is high. Hence, the relevance of this study exists. This is one of the very few *in vivo* studies in literature with such a large sample of fluorosed teeth where two bond promoters were compared to reduce bond failures

Table 1: Bond failure percentage compared in two groups

Group	*Failure*	*Successful*	*Total*	*Percentage failure*
Enhance LC	4	128	132	3.0
All-Bond 3	12	120	132	9.1
Total	16	248	264	6.1

Pearson's Chi-square value = 4.26, p = 0.039

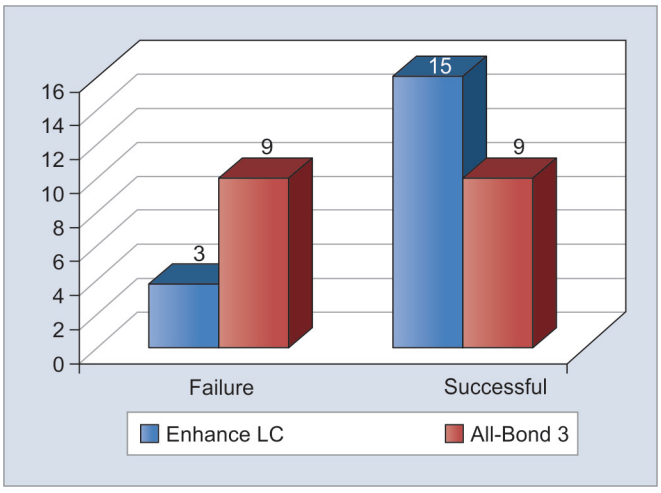


Graph 1: Bond failure percentage compared in two groups

Table 2: Number of patients with bond failure

Group	*Failure*	*Successful*	*Total*
Enhance LC	3	15	18
All-Bond 3	9	9	18
Total	12	24	36

Pearson's Chi-square value = 4.50, p = 0.034



Graph 2: Number of patients with bond failure

in compromised enamel when evaluated for 9 months after bonding.

In the present study, bond failures were observed for 9 months in each patient. If bond failures were to occur because of poor bonding potential to compromised enamel, it would normally happen in first few days or week after bonding. The longevity of bracket retention for the remainder of treatment in our study has a good prognosis, as we have surpassed the 9 month in service period. In Enhance LC group, four bonds failed and in All-Bond 3 group, 12 bond failures occurred which was statistically significant. In Enhance LC group, out of four bond failures, one bond failed in first 4 weeks interval and remaining three failed in the 9th month of evaluation period.

In All-Bond 3 group, 12 bonds failed, out of which seven bonds failed in the first 4 to 6 weeks duration and five bonds failed in the 8th month after starting treatment. Also in Enhance LC group, four bonds failed in three patients which may be attributed to local factors. Whereas in All-Bond 3 group, 12 bonds failures occurred in nine patients which was found to be statistically significant.

Vicente et al compared the effect of Enhance LC and All-Bond 2 on shear bond strength of orthodontic brackets.[18] They achieved greatest bond strength value using Light Bond Plus Enhance LC whereas no significant bond strength was increased using All-Bond 2 bond promoter. Wronko et al also observed that All-Bond 2 primer did not significantly affect the bond strength of composite resin to etched enamel.[24] These results are in correlation with finding of our study, whereas Egan et al revealed that application of Enhance LC on etched enamel surface or bracket base of a debonded bracket failed to increase rebond strength.[25]

Adanir et al showed that brackets bonded with Enhance LC on fluorosed enamel exhibited significant increase in bond strength.[26] This again supports the finding of the present study. Whereas Chung et al concluded that both Enhance LC and All-Bond 2 do not increase shear bond strength when used on new brackets but on sandblasted rebounded brackets, but All-Bond 2 significantly increased bond strength as compared to Enhance LC.[26] Hence, contradictory results exist in the literature concerning the effect of adhesion promoter agents on the bond strength. This can be explained by differences in the materials used.

There are many *in vitro* studies in the literature comparing the effects of bond promoters on fluorosed enamel but no *in vivo* studies have been performed till date to reduce bond failures in fluorosed enamel. Although *in vitro* shear bond tests with universal testing machines have been considered the standard for assessing bond strength values, they have some drawbacks. Some parameters of the oral environment cannot be simulated *in vitro*, and optimum conditions for bracket placement and moisture isolation exist only in the *in vivo* environment. *In vivo* studies have enabled the researchers to test bond strengths of brackets and adhesives after bonding procedures in actual clinical conditions.[18]

Overall-Bond failure rate was 6.1% in the present study when two groups were compared. All-Bond 3 group exhibited 9.1% bond failure as compared to Enhance LC where 3.03% bond failure rate was observed. Factors that could affect bond failure include contaminants, such as saliva, and the contents of some pastes, such as fluorides, oils or other agents.[27] Furthermore, the stress distribution at the bracket-adhesive interface is not homogenous.[28] Clinically, the Overall-Bond failure rate for brackets bonded directly to enamel has been reported to range from 4 to 30%.[29] The bond failure rate was double using All-Bond 3 adhesion promoter. Similarly, nine patients experienced bond failures with All-Bond 3 and only three patients in Enhance LC group.

Bond failure is highly inconvenient for patients and clinicians leading to longer treatment duration. The findings of present study suggest use of Enhance LC works better than All-Bond 3 to prevent bond failures in fluorosed enamel cases.

Hence, use of an adhesion promoter provides a clinically successful adhesion bonding protocol of orthodontic brackets to severly fluorosed teeth.

CONCLUSION

The null hypothesis that there would be no difference in bond failure rate used Enhance LC and All-Bond 3 on fluorosed enamel was rejected.

Following conclusions were drawn from the study:

- There was significant difference in bond failure rate on using Enhance LC and All-Bond 3 on fluorosed enamel.
- More number of patients experienced bond failures using All-Bond 3 as compared to Enhance LC as bond promotor.
- Enhance LC is more effective than All-Bond 3 to prevent bond failures in fluorosed enamel.

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