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EFFECT OF TWO REMINERALIZING AGENTS ON SHEAR BOND STRENGTH OF TWO ORTHODONTIC COMPOSITES(AN IN-VITRO STUDY)

Seif Eldein Mohamed Kamel Ayad [1], Hanady Mohamed Samih[2] Ahmed Abdel- Fattah Ramadan[3]

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KEYWORDS

Bleaching; CPP-ACP; fluoride; remineralization; shear bond strength

- E-mail address: seifeldeinayad@gmail.com

1. Postgraduate student at orthodontics department, Faculty of Dentistry, Suez Canal University.
2. Professor of Orthodontics, Faculty of Dentistry Suez Canal University, Ismailia, Egypt.
3. Professor of Orthodontics, Faculty of Dentistry Suez Canal University, Ismailia, Egypt.

ABSTRACT

Introduction: Enamel demineralization and white spot lesions associated with bleaching are some of the greatest challenges. Tooth pre-treatments with these agents on the enamel can therefore interfere with the bonding mechanism and the bond strength of brackets. **Aim**: The aim of this study was to compare the effect of CPP-ACP and fluoridated CPP-ACP on the shear bond strength of two different types of composites on bleached teeth. **Methods**: Seventy five sound human premolars were subjected to bleaching with an In-office whitening gel. After bleaching, the samples were randomly divided into six equal experimental groups: Group I and II (control), the brackets were bonded without any surface treatment; Group III and IV, the enamel surfaces were treated with CPP-ACP paste before bonding; Group V and VI, the teeth were treated with F-CPP-ACP paste before bonding. The samples in Groups I, III and IV bonded with Transbond XT composite and samples in Groups II, IIII and VI bonded with Transbond supreme composite. SEM photomicrographs of a tooth from each group were taken to observe the enamel surface. The brackets were bonded to the buccal enamel using a conventional method. Shear bond strength of brackets and ARI scores were measured. Data were analyzed with ANOVA test at the $P < .05$ level. **Results**: ANOVA comparison of six groups revealed statistically significant differences. There is a significant differences were found between the control groups and CPP-ACP-treated groups. However, highest Tensile SBS values was recorded for group III (13.61±4.69Mpa) and the lowest value was recorded for group II (7.62±3.68 Mpa). ARI scores were significantly different among the six groups ($P < .001$). **Conclusion**: CPP-ACP and CPP-ACP-F promoted the formation of hydroxyapatite and fluorapatite on weak bleached enamel surface.

INTRODUCTION

Enamel demineralization and white spot lesions associated with bleaching are some of the greatest challenges faced by clinicians not only for esthetic reasons but also because this subsurface demineralization represents the first stage of caries formation[1-3].

There are different methods to reduce enamel demineralization during orthodontic treatment without compromising the bond strength of the orthodontic brackets. The most common method was the use of fluoride-containing mouth rinses, gels, and kinds of toothpaste.

However, studies found a significant association between patient compliance to the rinsing program and the reduction in the development of white spot lesions[4, 5].

Preventive measures which not depend on the patient's compliance have been developed to solve the problem of demineralization. These included: topical applications of preventive agents as fluoride and antibacterial agents incorporated in the adhesive resin, fluoride-releasing adhesives, caries infiltration resins, laser irradiation, bioactive glass-containing adhesives, and enamel deproteinizing agents[6-8].

Recently, a milk protein derivate, casein-phosphopeptide–amorphous calcium-phosphate (CPP–ACP), has been recommended for caries prevention and enamel remineralization. The topical application of CPP–ACP provides saturation of the enamel structure by the localization of the ACP on the tooth surface. The presence of CPP can guarantee the availability of calcium and phosphate in a soluble and biological form for all oral cavities and even providing a large reserve in dental plaque[9-10].

In the current study, we studied the effect of fluoride-containing and non-fluoride-containing casein-phosphopeptide-amorphous calcium-phosphate (CPP–ACP) on the shear bond strength of different adhesives of the teeth that have been bleached.

MATERIAL AND METHODS

The present study was performed on 75 upper and lower premolar teeth which were extracted for orthodontic reasons after the approval of the study protocol by the Research Ethics Committee of the Faculty of Dentistry, Suez Canal University.

For SBS test in 72 premolars were used. For scanning electron microscopic (SEM) observations, the remaining three premolars were used.

Inclusion criteria of the teeth incorporated in the study [1]:

- Freshly extracted premolars.
- Absence of any enamel malformation.
- Absence of any enamel facets.
- Absence of any visual chipping of enamel.
- Free of caries and white spots as the premolars were visually inspected and detected with a sharp explorer.
- Free of any visual enamel cracks.

The material used in this study were:

1- Bleaching material: Opalescence Boost in-office tooth whitening gel (40% hydrogen peroxide).

2- Remineralizing agents :

   a. Casein phosphopeptide- amorphous calcium phosphate (CPPACP).

   b. Fluoride -containing casein phosphopeptide amorphous calcium phosphate (F-CPP-ACP).

3- Light cure adhesive materials :

   a. Transbond XT light cure Paste adhesive.

   b. Transbond Supreme light cure flowable adhesive.

The six groups were divided as follows according to material treatment:

Group I: Bleached teeth bonded with conventional composite Transbond XT. Group II: Bleached teeth bonded with low viscosity light cure adhesive Transbond Supreme. Group III: Bleached teeth treated with a paste containing CPP-ACP (GC Tooth Mousse RECALDENT) then bonded with conventional composite Transbond XT. Group VI: Bleached teeth treated with a paste containing

CPP-ACP (GC Tooth Mousse RECALDENT) then bonded with low viscosity light cure adhesive Transbond Supreme. Group V: Bleached teeth treated with a paste containing fluoridated CPP-ACP (Gc MI paste plus) then bonded with conventional composite Transbond XT. Group VI: Bleached teeth treated with a paste containing fluoridated CPP-ACP (Gc MI paste plus) then bonded with low viscosity light cure adhesive Transbond Supreme.

Mounting teeth specimens in acrylic blocks:

The teeth were mounted in an acrylic base to facilitate their use during all steps of the procedure. The acrylic bases are differentiated by color coding into yellow, green, red, orange, light blue, and dark blue for groups I , II, III, VI, V and VI respectively.

Teeth bleaching:

Bleaching was done for all samples in all groups. The gel was allowed to remain on the teeth for 20 minutes, periodically checking and re-applying areas that have thinned or need replenishing.

The gel was removed from the teeth using a surgical suction tip. When the gel was not visible, the tooth was rinsed and air-dried [(2)].

Remineraliztion procedure:

1- The specimens in groups III and IV were treated with a paste containing CPP-ACP as follow: The agent was left undisturbed on the tooth surface for 5 minutes and then rinsed. After 6 hours, the topical agent was reapplied to the tooth surface using the same method.

2- The specimens in groups V and VI were treated with a paste containing F-CPP-ACP as follow: - The agent was left undisturbed on the tooth surface for 5 minutes and then rinsed. After 6 hours, the topical agent was reapplied to the tooth surface using the same method. This procedure was repeated 10 times for remineralization. During these cycles, all teeth were stored in artificial saliva [(3)]. After this step, brackets were bonded using the standard protocol.

Bonding technique:

All the enamel surfaces of the teeth were treated with 37% phosphoric acid for 20 seconds then rinsed with the air-water syringe for 30 seconds and air-dried with moisture-free compressed air for 10 seconds until the surface of the etched enamel showed a frosty chalky appearance.

Group I :

After etching, the twelve specimens in this group were bonded with Transbond XT composite as follow:

- Transbond XT primer was applied to the etched surface and the tooth was sprayed with a stream of oil-free compressed air to ensure that a thin layer of primer remained then light cured with a dental LED curing device for 10 seconds.
- Stainless steel premolar brackets (Leone bracket) having a base area of 14.08 mm 2 were bonded using Transbond XT composite (3M Unitek)[(4)].
- A sufficient amount of Transbond XT was applied on the bracket base and the bracket was placed on the middle third of the buccal surface along the long axis of the crown and was pressed in the middle to allow for the escape of excess adhesive. The flush material was removed carefully from the periphery of the bracket with a sharp explorer then the adhesive was light cured with a LED for a total of 20 seconds (5 seconds for each side; occlusal, gingival, mesial, and distal).

Group II:

The twelve specimens in this group were bonded with low viscosity light cure Transbond Supreme as previously mentioned in group 1.

Group III:

- The twelve specimens were bonded after treatment with CPP-ACP.
- This group was bonded with Transbond XT composite as previously mentioned in group 1.

Group IV:

- The twelve specimens were bonded after treatment with CPP-ACP
- This group was bonded with Transbond Supreme composite as previously mentioned in group 2.

Group V:

- The twelve specimens were bonded after treatment with fluoride-containing CPP-ACP.
- This group was bonded with Transbond XT composite as previously mentioned in group 1.

Group VI:

- The twelve specimens were bonded after treatment with fluoride-containing CPP-ACP
- This group was bonded with light cure Transbond Supreme adhesive as previously mentioned in group 2.

Shear bond strength test:

After bonding the orthodontic braces, all the tested groups were subjected to the shear bond test.

The shear bond test was performed with a chisel blade mounted on a cross-head of a universal testing machine (model 3345)[1]* with a load cell of 5 Kilo Newton (KN). The thickness of a chisel blade is 0.5mm.

Evaluation of the amount of Adhesive Remnant Index (ARI):

After subjecting the different groups to debonding and establishing the sites of adhesive fracture, each tooth surface was examined with a streomicroscope of 20 x magnification to assess the amount of adhesive remnant, using adhesive remnant index [(5)].

The samples were scored as follows:

- Score 0: No adhesive was found on the tooth surface.
- Score 1: Less than 50% adhesive remained on the tooth surface.
- Score 2: More than 50% adhesive remained on the tooth surface.
- Score 3: All the adhesive remained on the tooth surface.

Scanning Electron Microscope:

Three premolars were used for ultrastructural examination of the enamel surfaces by SEM[2].**

SEM observations were carried out to observe the bleached enamel surfaces without pretreatement, with CPP-ACP treatment and with F-CPP-ACP treatment.

Statistical analysis:

Data were subjected to statistical analyses using a Computer program SPSS software for windows version 22.0 (Statistical Package for Social Science, Armonk, NY: IBM Corp) at significant levels 0.05 (P-Value ≤0.5).

* nstron industrial products, Norwood, MA, USA.

** A Scanning electron microscope, Quanta FEG 250, FEI Company, US

RESULTS

Results of Shear Bond Strength of all tested groups :

As presented in table 1,the highest value was recorded in group 3 (13.61±4.69Mpa), while the lowest one was recorded in group 2 (7.62±3.68 Mpa). Group 1, 4, 5, and 6 had the values (8.72±1.47 Mpa), (12.98±6.44 Mpa), (11.20±4.77 Mpa), and (10.32±4.51 Mpa) respectively.

Results of Adhesive Remanant Index:

The statistical analysis of ARI of different tested groups is shown in table (2) and figure (1).

Regarding ARI score 0: Group 1 had the highest percentage (58.3%). Group 2 was (16.7%) and groups 4 and 6 were (16.7%) then groups 3 and 5 (8.3%).***Regarding ARI score 1***: Group 2 had the highest percentage (33.3%). Group 5 was (25%), groups 1, 4, and 6 were (16.7%) and group 3 was (8.3%). ***Regarding ARI score 2***: Group 3 and group 6 had the highest percentage (25%). Group 4 and group 5 were (16.7%) and groups 1 and 2 were (8.3%). ***Regarding ARI score 3*** : Group 3 had the highest percentage (58.3%). Group 4 and group 5 were (50%) and group 6 was (41.6%) then group 1 was (16.7%) and group 2 was (8.3%).

Table (1) *Descriptive statistics of the mean values and standard deviation of shear bond strength (Mpa) of the six tested groups.*

Groups	Mean	SD	Min	Max
Group 1	**8.72^{b}**	**1.47**	**3.2**	**13.4**
Group 2	**7.62^{b}**	**3.68**	**3.3**	**17.7**
Group 3	**13.61^{a}**	**4.69**	**8.1**	**27.2**
Group 4	**12.98^{a}**	**6.44**	**6.3**	**27.1**
Group 5	**11.20^{ab}**	**4.77**	**6.9**	**25.6**
Group 6	**10.32^{ab}**	**4.51**	**5.1**	**23.4**
P-Value	**0.014****			

Values with the same superscript letters indicate significant differences at $P < 0.001$.

Table (2) *Frequency Distribution of Adhesive Remnant Index (ARI) Scores of all groups:*

	Group1		*Group2*		*Group3*		*Group4*		*Group5*		*Group6*		*P-value*
Score	N	%	N	%	N	%	N	%	N	%	N	%	
Score 0	7	58.3$^{a\,A}$	6	50.0$^{a\,A}$	1	8.3$^{c\,B}$	2	16.7$^{b\,B}$	1	8.3$^{c\,B}$	2	16.7$^{c\,B}$	0.0**
Score 1	2	16.7$^{b\,B}$	4	33.3$^{b\,A}$	1	8.3$^{c\,B}$	2	16.7$^{b\,B}$	3	25.0$^{b\,A}$	2	16.7$^{c\,B}$	0.0**
Score 2	1	8.3$^{b\,B}$	1	8.3$^{c\,B}$	3	25.0$^{b\,A}$	2	16.7$^{b\,B}$	2	16.7$^{c\,B}$	3	25.0$^{b\,A}$	0.0**
Score 3	2	16.7$^{b\,B}$	1	8.3$^{c\,B}$	7	58.3$^{a\,A}$	6	50.0$^{a\,A}$	6	50.0$^{a\,A}$	5	41.6$^{a\,A}$	0.0**
P-value	0.04*		0. 04*		0.04*		0. 04*		0.04*		0.04*		

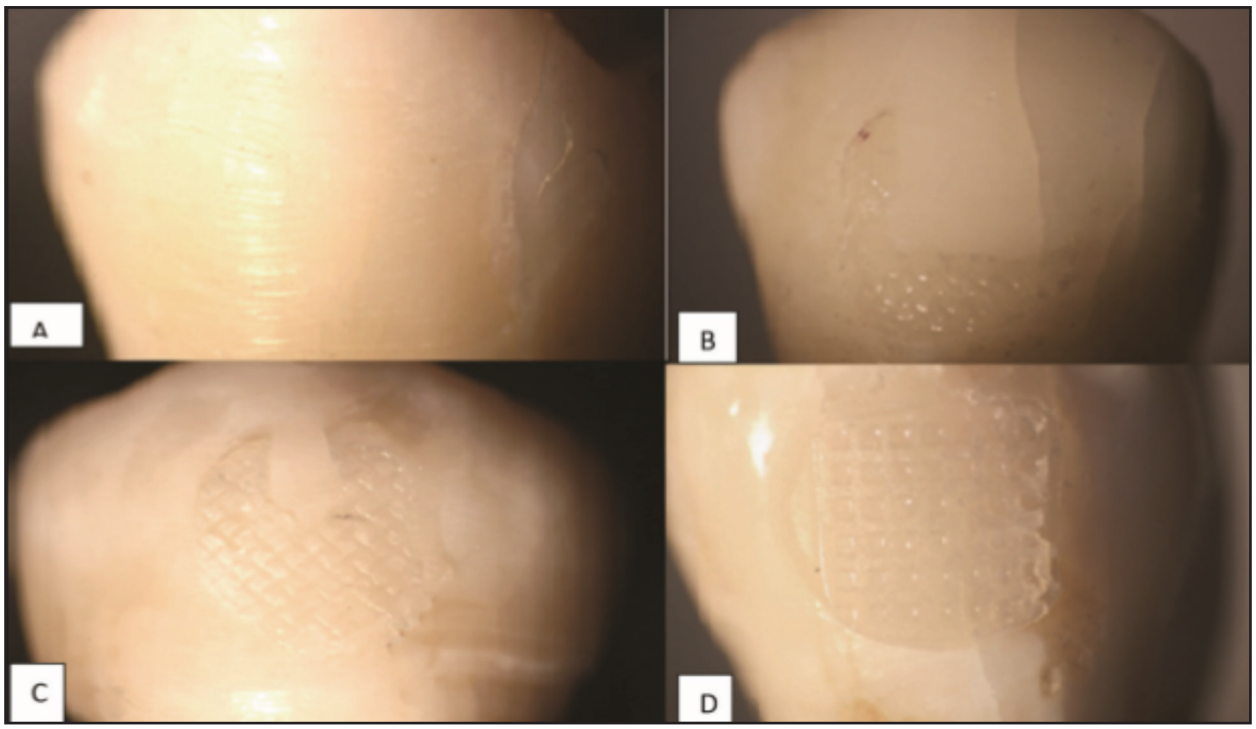

Fig. (1) Stereo microscopic image revealing adhesive enamel index on enamel surface after debonding; (A) score 0, (B) score1, (C) score 2, (D) score 3.

DISCUSSION

The present study was conducted to evaluate and compare the effect of CPP-ACP (GC Tooth Mousse) and fluoridated CPP-ACP (GC MI PASTE PLUS) on the shear bond strength of two different types of composites Transbond XT adhesive and Transbond Supreme adhesive on bleached teeth with Opalescence Boost 40% hydrogen peroxide tooth whitening system) and to determine the mode of failure after shear bond strength test.

In the present study, the samples in **groups I and II** were bleached only with Opalescence boost 40% hydrogen peroxide and bonded with Transbond XT and Transbond Supreme adhesives respectively**, groups III and VI were** treated with CPP-ACP after bleaching then bonded with Transbond XT and Transbond Supreme adhesive respectively**. Groups V and VI were** treated with fluorated CPP-ACP after bleaching then bonded with Transbond XT and Trandbond Supreme respectively.

The highest value was recorded in group III (13.61±4.69Mpa). This could be due to the application of CPP-ACP. The increased mineral content in dental hard tissue produced by CPP-ACP as it was assumed to provide a reactive substrate by precipitation of calcium phosphate led to identical enamel surface composition which led to identical bonding with an adhesive. This amorphous calcium phosphate (ACP) stabilized with casein phosphopeptides (CPP) affords an excellent bioavailable Ca and P reservoir. The lower results of shear bond strength of group 1 might be due to the mineral loss in enamel after the bleaching

process as oxidation-reduction processes caused by bleaching agents give rise to deconstruct the organic and inorganic matrix of the enamel.

This was in agreement with Veli et al [6], Baka et al [7], Usal et al [8], De Vasconcelos et al [9] and, Banu Saglam-Aydinatay et al [10].

On the other hand, Ladhe et al [11] and Cossellu et al [12] found that the shear bond strength of orthodontic brackets was not affected significantly by the use of CPP-ACP when used with a light-cure bonding system. Naseh et al [13] found that that the use of CPP-ACP can be considered a prophylactic application as these agents did not compromise bracket bond strength although they did not reduce iatrogenic damage to the enamel.

The results were inconsistent with the results of Cehreli et al [14] as it revealed that enamel pre-treatment with CPP-ACP significantly reduced the SBS of the etch-and-rinse adhesive. Lu et al [15] revealed that after tooth bleaching, CPP-ACP treatment had little influence on the shear bond strength of orthodontic brackets. This difference in results might be due to the mode of adhesion and the sample size in that studies which were different than that used in the present study.

While the lowest one was recorded in group 2 (7.62±3.68 Mpa). The lower value of group 2 might be due to the mineral loss in enamel after the bleaching process as the oxidation-reduction processes caused by bleaching agents give rise to deconstruct the organic and inorganic matrix of the enamel.

This was in agreement with Bishara et al [16], Ryou et al[17] and, Albaladejo et al [18] which supported that the flowable composites can be effectively applied to orthodontic bracket bonding as the most effective factor was the CPP-ACP than the type of adhesive on shear bond strength.

Bengassem et al [19] revealed that Transbond Supreme demonstrated superior survival under loading than Transbond XT.

This result disagrees with Pick et al [20] which showed that the flowable resin-based composites tested had low mean TBS values. The disagreement might be due to the different protocol as it was done on bovine incisors and flowable resin-based material used in that study.

Failure at the bracket-adhesive interface has been suggested to be more desirable to prevent enamel damage. However, another opinion supports bond failure between enamel and adhesive so that there will be less adhesive residue to remove at the time of debonding.

In the present study, there was a greater frequency of ARI scores of 0 and 1 in groups 1 and 2, indicating that the failures were mainly at the resin tooth interface due to weak bonding properties of bleached enamel. In group 3 and group 4, there was a higher frequency of ARI scores of 2 and 3, indicating adhesive failures between the bracket and the resin due to the strong bond between the enamel and composite. In groups 5 and 6, there was also a higher frequency of ARI scores of 2 and 3, indicating adhesive failures between the bracket and the resin.

The ARI scores indicated that more composite remnant on the teeth when the preventive agents were applied after bleaching as the bond failure occurred at the bracket-adhesive interface. This was characterized by a shift from ARI scores of 0 and 1 in groups 1 and 2 to ARI scores of 2 and 3 after application of the remineralizing agents in other groups. In the present study, the distribution of ARI scores were in accordance with the SBS values of the groups.

Taking into account that the minimum accepted SBS value for clinical use was 5.9–7.8-MPa According to Reynolds [5], SBS values of all groups were adequate for orthodontic purposes. The results of this study showed that the application of CPP-ACP and CPP-ACPF significantly increases the SBS of brackets when compared to those on bleached enamel without pretreatment methods making bond failure occurred at the bracket-adhesive interface and the possibility of enamel damage after debonding decreases.

The findings of this study reinforce the need for CPP-ACP and CPP-ACP-F therapy in patients who have bleaching procedures before orthodontic bonding.

CONCLUSION

From the results of the present study, the following conclusion could be drawn:

1. Orthodontic bonding should be delayed if patients have a history of in-office bleaching with 40% hydrogen peroxide.
2. The application of CPP-ACP paste after bleaching increased the mean value of shear bond strength of orthodontic adhesives.
3. The application of fluoride-containing CPP-ACP paste after bleaching increased the mean value of shear bond strength of orthodontic adhesives.

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