Effects of Three Remineralizing Agents in the Shear Bond Strength of Orthodontic Brackets

AA Nuñez-Solano, LE Rodriguez-Vilchis, RJ Scougall-Vilchis, R Contreras-Bulnes, U Velazquez-Enriquez

Affiliations:
[1]Autonomous University State of Mexico, School of Dentistry, Dental Research Center and Advanced Studies (CIEAO) "Dr. Keisaburo Miyata", Jesus Carranza corner Paseo Tollocan, Col University, ZC 50130 Toluca City, State of Mexico, Mexico.

Correspondence:
Dr S-V Rogelio
School of Dentistry
Dental Research Center and Advanced Studies
Autonomous University State of Mexico,
Mexico
E-mail: rogelio_scougall@hotmail.com

Short title: Remineralizing Agents and Bond Strength of Brackets

Synopsis: This study evaluates the effect of three remineralizing agents, in the shear bond strength (SBS) of orthodontic brackets. The application of these remineralizing agents had favorable values that did not affect the SBS and thus orthodontic brackets.

ABSTRACT

Objective: This study aimed to evaluate the effect of three remineralizing agents, in the shear bond strength (SBS) of orthodontic brackets.

Methods: A total of 120 extracted human premolars were randomly divided into 4 groups (n=30). Group I was the control group, in which the enamel was etched with 35% phosphoric acid, and stainless steel brackets were bonded with Transbond XT Adhesive, then light cured for 6 seconds with an Ortholux lamp. In the remaining 3 groups the same adhesive procedure that was described in the control group was made. However, before being light-cured the remineralizating agents were applied on the surrounding area of the bracket: group II, Clinpro XT Varnish; group III, MI Paste Plus; group lV, Fluor Protector. The samples were stored (37 °C, 24 h) and debonded with a universal testing machine. The adhesive remnant index (ARI) including enamel fracture score were also evaluated.

Results: The SBS values of groups II (15.7 ± 3.4 MPa) and III (15.8 ± 4.2 MPa) were significantly higher than the group IV (11.0 ± 3.8 MPa). The ARI in Group II showed the lowest amount of adhesive remaining and the largest amount of adhesive was shown by Group IV. No enamel fractures were observed during the tests.

Conclusion: The use of three remineralizing agents did not compromise bracket bond strength; and they can be considered as an alternative preventive application in orthodontic practice.

Keywords: Shear bond strength; Remineralizing; Enamel; Orthodontic brackets

INTRODUCTION

The remineralizing agents are of great importance in the field of orthodontics, as during orthodontic treatment is more difficult to make a good hygiene control, therefore it increases caries risk due to the presence of brackets, bands, archwires and excess bonding material around the base of the bracket, which creates sites where biofilm is usually more easily accumulated (1-4).

Remineralization is a preventive measure to avoid injuries caused by acids or other factors, reversing the initial damage caused by the decay to the tooth structure, making possible the remineralization of injuries on the surface (5-9).

The demineralization-remineralization process is a continuous, variable cycle due to the production of acids that affect the enamel surface, caused by food intake, specifically carbohidrates (10-12).

The white spot lesions are the first clinical expression of demineralization that occurs on the enamel surface (13, 14). It is clinically identified as a whitish area with loss of translucency that may affect one or more teeth and occurs in both temporary as in permanent teething (15, 16).

The presence of such injuries during orthodontic treatment is caused by multiple factors such as biofilm. It has been reported that between 2% and 96% of orthodontic patients are likely to develop the white spot lesion during treatment, and its presence can be detected four weeks after placement of fixed appliances orthodontic (17).

Aesthetics is the main reason that patients go to orthodontic treatment to achieve a beautiful smile. Expectations after removal of brackets may be affected by white spot lesions, common negative sequel after orthodontic treatment. In this context, the treatment of enamel surfaces with different preventive agents has been suggested before and during orthodontic practice.

Fluoride is widely used to prevent caries; its incorporation into the enamel provides a less soluble surface to acid attacks. The fluoride ions can prevent demineralization and promote remineralization.

Acid dental materials used in orthodontic treatments can increase the rate of decay. In addition, fluoride can be used to reduce this iatrogenic enamel damage when applied before bonding the bracket. However, the surface treatment of enamel with fluoride could affect shear bond strength (SBS) of brackets (18, 19).

In this sense, it is necessary to analyze the placement of these materials, as when performing a treatment with brackets, the teeth must meet certain characteristics. Therefore, the purpose of this research is to identify the effect of three remineralizing agents in the shear bond strength (SBS) of orthodontic brackets.

MATERIALS AND METHODS

Shear bond strength

Teeth

A total of 120 human premolars extracted for orthodontic reasons were stored in thymol solution 0.1% (wt/vol). The study was approved by the University State of Mexico, School of Dentistry / Ethics Committee. Written informed consent was obtained from each participant prior to enrolment. The selection criteria included intact buccal enamel, the absence of pretreatment with chemical agents and the absence of cracks and dental caries (19). Buccal tooth surface was polished for 10 seconds using a rubber cup at low speed and fluoride free prophylaxis paste. The teeth were washed with water for 30 seconds and dried with oil-free compressed air.

Brackets

A total of 120 stainless steel brackets for premolars (.018", Alexander Signature Ormco Corp, Orange, Calif.) were used.

Bonding procedure

The teeth were randomly divided into four groups (n=30/group):

Group I (Control): The enamel was etched with 35% phosphoric acid (Ultra-Etch, Ultradent, USA) for 15 seconds, washed with running water and dried with oil-free compressed air to observe a whitish appearance on the surface; subsequently, the adhesive was placed on the buccal tooth surface conditioning while Transbond XT (3M Unitek Monrovia, Calif), resin was applied to the bracket base for cementation, then light cured for 6 seconds with a Ortholux lamp (3M Unitek Monrovia, Calif).

Group II (Experimental): Clinpro XT Varnish (3M ESPE). Same bonding procedure described in the control group was performed; however, prior to curing, Clinpro XT Varnish (3M ESPE) was applied to the periphery of the bracket. The remineralizing was dispensed into a mixing pad, then both components of the material were mixed for 15 seconds and a thin layer was placed on the tooth surface and cured for 20 seconds.

Group III (Experimental): MI Paste Plus (GC)

The same procedure was carried out in the control group without a change before curing, MI Paste Plus (GC) was applied to the periphery of the bracket; applying a sufficient amount in the tooth surface using a cotton swab and left in for 3 minutes.

Group IV (Experimental): Fluor Protector (Ivoclar Vivadent)

It was carried out the same procedure in the control group, however before photopolymerization Fluor Protector (Ivoclar Vivadent) was applied on the periphery of the bracket. A thin layer of

varnish using a disposable applicator, dispersing and drying the varnish uniformly with air syringe was placed.

Storage

A stainless steel wire (0.017 × 0.025 in) was ligated into the slot of each bracket to reduce any deformation during the eviction process. The teeth were fixed in acrylic resin using a jig oral tooth surface parallel to the applied force during the test of SBS. The teeth were stored in distilled water at 37 ° C for 24 h (20).

SBS test

An occlusogingival load was applied at the level of the bracket-tooth to produce a shear force interface, which was done with the flattened end of a steel bar attached to the universal testing machine (Shimadzu AGS-X, Kyoto, Japan). The values of debonding resistance were measured at a speed of 0.5 mm / min, the load applied to detachment was recorded in kilograms and converted to megapascals (MPa). The descriptive statistical analysis was performed to calculate the mean, standard deviation and range. Similarly, the Scheffe test (one-way ANOVA) was applied with predetermined significance at $p<0.05$.

Adhesive remnant index (ARI)

Once the SBS test, the amount of residual adhesive on the surface of the teeth was evaluated according to the original score of ARI. The chi-square test was used to analyze the ARI.

RESULTS

Shear bond strength

The SBS values (in MPa) and descriptive statistics are shown in Table 1. All groups had greater SBS than the values established as necessary to support orthodontic forces (5.9 to 7.8 MPa);

however, those values achieved by the groups II (15.7±3.4 MPa) and III (15.8±4.2 MPa) were significantly higher than the group IV (11.0±3.8 MPa). On the other hand the control group showed no differences significant with any group.

Adhesive remnant index (ARI)

The ARI scores for adhesive remaining after debonding are shown in Table 2. The comparison of the test results with the chi-square test indicates that the four groups are significantly different ($p = 0.0001$). Group II showed the lowest amount of adhesive remaining and the largest amount of adhesive remaining was shown by Group IV. No enamel fractures were observed during the tests.

DISCUSSION

The demineralization of adjacent enamel to orthodontic brackets is a significant clinical problem. White spot lesions are developed as a result of prolonged plaque accumulation on the affected surface, this is common as a result of inadequate oral hygiene. However, the application of remineralizing agents may reduce decalcification during fixed orthodontic treatment. The mechanism by which the fluoride reduces decalcification and caries has also shown an increase in the resistance of enamel to acids. The fluoride deposits in hydroxyapatite form fluorapatite, which is claimed to affect the bond strength and/or debonded interface (21, 22).

In this *in vitro* study, we examined the effects of three remineralizing agents in the SBS of orthodontic brackets. The application of remineralizing has aroused great interest among clinicians since maintaining a healthy and intact enamel surface after removing the brackets is one of the primary goals of the orthodontist. Because of this, the great advantages of remineralizing are reflected in the manufacture of new products on the market.

According to some reports, MI Paste Plus restores minerals to the teeth and helps to stimulate saliva production. It contains Casein phosphopeptide–amorphous calcium phosphate (CPP-ACP), a special milk-derived protein, which is a potential breakthrough in oral health care in helping to remineralize teeth. The casein phosphopeptide stabilizes the amorphous calcium phosphate in solution, it maintains a high concentration of calcium gradients and phosphate in the white spot lesion, thus effecting high rates of enamel remineralization (23-25).

On the other hand; Clinpro XT Varnish it is an ionomer varnish, provides the dental organ with one of the biggest benefits is adhering to the tooth structure, release of fluoride, calcium and phosphate potentially help the mineralizing.

The findings of this study suggest that these remineralizing agents may be an alternative for the prevention of white spot in the tooth enamel prior to cementation of orthodontic brackets as favorable values, which do not affect the SBS, were found. However, the SBS values of groups II (Clinpro XT Varnish) and III (MI Paste Plus) were significantly higher than the groups I (Control) and IV (Fluor Protector).

Baysal et al (26), found that when performing a micro-abrasion and remineralization of enamel in a previously demineralized improves the bonding surface of the bracket, obtaining higher values in the adhesion strength compared to the control group where no remineralizante was used. Uysal et al. (27), suggests that CPP-ACP pretreatment improves bonding demineralized enamel. Similar studies, as Xiaojun et al. (28), has shown that pretreatment with remineralizing agents can be used safely before bonding the brackets, because the SBS was higher than recommended for orthodontic tooth movement.

On the other hand, Kecik et al. (29), reported that pretreatment with CPP-ACP and acidulated phosphate fluoride (APF) does not affect the SBS, obtaining values well above the required, suggesting that could be applied safely before bonding the bracket.

In this study data are provided on the effect of remineralizing agents in SBS. However, should be considered the limitations of in vitro tests when interpreting the results.

CONCLUSIONS

In this *in vitro* study, the following conclusions can be drawn:

-The application of these remineralizing agents had favorable values that did not affect the SBS and thus orthodontic brackets.

-The SBS reduced significantly by placing the agent tested in group IV; however, it may not affect the orthodontic treatment; since the force is greater than required.

-Regarding the ARI no enamel fractures were observed in the dental organ. The highest percentage rate was between 2 and 3 so a suitable adhesion could be observed between the resin and the tooth in this index of reference.

-Both agents tested in group II and III showed that, from the ecological point of view, can be used with the application of a small amount of material, while the rest of the content is stored in its container, which implies a reduction in the investment of dental materials and an easy handling for dental practitioners. However further studies are necessary to analyze the real benefits in clinical practice and preventive effects.

AUTHOR'S NOTE

RJ Scougall-Vilchis provided oversight to study, participated in data interpretation and revision of manuscript, and approved final version. AA Nuñez-Solano oversaw data collection, conducted data analysis, wrote manuscript and approved final version. LE Rodriguez-Vilchis participated in

study design, data analysis and interpretation, critically revised manuscript and approved final version. R Contreras-Bulnes and U Velazquez-Enriquez participated in study design, interpretation of data and revision of manuscript and approved final version.

REFERENCES

1. Richter AE, Arruda AO, Peters MC, Sohn W. Incidence of caries lesions among patients treated with comprehensive orthodontics. Am J Orthod Dentofacial Orthop 2011; 139: 657–64.
2. Travess H, Roberts-Harry D, Sandy J. Orthodontics. Part 6: Risks in orthodontic treatment. Br Dent J 2004; 196: 71–7.
3. Sudjalim TR, Woods MG, Manton DJ, Reynolds EC. Prevention of demineralization around orthodontic brackets in vitro. Am J Orthod Dentofacial Orthop 2007; 131: 705.e1–9.
4. Tabrizi A, Cakirer B. A comparative evaluation of casein phosphopeptide-amorphous calcium phosphate and fluoride on the shear bond strength of orthodontic brackets. Eur J Orthod 2011; 33: 282–7.
5. Cacciafesta V, Sfondrini MF, Calvi D, Scribante A. Effect of fluoride application on shear bond strength of brackets bonded with a resin-modified glass-ionomer. Am J Orthod Dentofacial Orthop 2005; 127: 580-3.
6. Shungin D, Olsson AL, Persson M. Orthodontic treatment-related white spot lesions: a 14-year prospective quantitative follow-up, including bonding material assessment. Am J Orthod Dentofacial Orthop 2010; 138: 136-7.
7. Farhadian N, Miresmaeili A, Eslami B, Mehrabi S. Effect of fluoride varnish on enamel demineralization around brackets: an in-vivo study. Am J Orthod Dentofacial Orthop 2008; 133: S95–8.
8. Guzmán-Armstrong S, Chalmers J, Warren JJ. Ask us. White spot lesions: prevention and treatment. Am J Orthod Dentofacial Orthop 2010; 138: 690–6.

9. Mehta R, Nandlal B, Prashanth S. Comparative evaluation of remineralization potential of casein phosphopeptide-amorphous calcium phosphate and casein phosphopeptide-amorphous calcium phosphate fluoride on artificial enamel white spot lesion: an in vitro light fluorescence study. Indian J Dent Res 2013; 24: 681–9.

10. Jayarajan J, Janardhanam P, Jayakumar P; Deeptika. Efficacy of CPP-ACP and CPP-ACPF on enamel remineralization - an in vitro study using scanning electron microscope and DIAGNOdent. Indian J Dent Res 2011; 22: 77–82.

11. Zhou C, Zhang D, Bai Y, Li S. Casein phosphopeptide–amorphous calcium phosphate remineralization of primary teeth early enamel lesions. J Dent 2014; 42: 21–9.

12. Tschoppe P, Zandim DL, Martus P, Kielbassa AM. Enamel and dentine remineralization by nano-hydroxyapatite toothpastes. J Dent 2011; 39: 430–7.

13. Willmot DR. White lesions after orthodontic treatment: does low fluoride make a difference? J Orthod 2004; 31: 235–42.

14. Livas C, Kuijpers-Jagtman AM, Bronkhorst E, Derks A, Katsaros C. Quantification of white spot lesions around orthodontic brackets with image analysis. Angle Orthod 2008; 78: 585–90.

15. Staudt CB, Lussi A, Jacquet J, Kiliaridis S. White spot lesions around brackets: in vitro detection by laser fluorescence. Eur J Oral Sci 2004; 112: 237–43.

16. Sudjalim TR, Woods MG, Manton DJ. Prevention of white spot lesions in orthodontic practice: a contemporary review. Aust Dent J 2006; 51: 284–9.

17. Mayne RJ, Cochrane NJ, Cai F, Woods MG, Reynolds EC. In-vitro study of the effect of casein phosphopeptide amorphous calcium fluoride phosphate on iatrogenic damage to enamel during orthodontic adhesive removal. Am J Orthod Dentofacial Orthop 2011; 139: e543–51.

18. Kimura T, Dunn WJ, Taloumis LJ. Effect of fluoride varnish on the in vitro bond strength of orthodontic brackets using a self-etching primer system. Am J Orthod Dentofacial Orthop 2004; 125: 351–6.

19. Reynolds EC, Cai F, Cochrane NJ, Shen P, Walker GD, Morgan MV, *et al*. Fluoride and casein phosphopeptide-amorphous calcium phosphate. J Dent Res 2008; 87: 344–8.

20. Scougall-Vilchis RJ, Mimura SI, Yamamoto K. Propiedades de un adhesivo ortodóncico liberador de fluoruro que contiene partículas de relleno tipo S-PRG. Rev Esp Ortod 2007; 37: 119–26.

21. Chapman JA, Roberts WE, Eckert GJ, Kula KS, González-Cabezas C. Risk factors for incidence and severity of white spot lesions during treatment with fixed orthodontic appliances. Am J Orthod Dentofacial Orthop 2010; 138: 188–94.

22. Farrow ML, Newman SM, Oesterle LJ, Shellhart WC. Filled and unfilled restorative materials to reduce enamel decalcification during fixed-appliance orthodontic treatment. Am J Orthod Dentofacial Orthop 2007; 132: 578.e1–6.

23. Huang GJ, Roloff-Chiang B, Mills BE, Shalchi S, Spiekerman C, Korpak AM, *et al*. Effectiveness of MI Paste Plus and PreviDent fluoride varnish for treatment of white spot lesions: a randomized controlled trial. Am J Orthod Dentofacial Orthop 2013; 143: 31–41.

24. Oliveira GM, Ritter AV, Heymann HO, Swift E Jr, Donovan T, Brock G, *et al*. Remineralization effect of CPP-ACP and fluoride for white spot lesions in vitro. J Dent 2014; 42: 1592–602.

25. Rahiotis C, Vougiouklakis G. Effect of a CPP-ACP agent on the demineralization and remineralization of dentine in vitro J. Dent 2007; 35: 695–8.

26. Baysal A, Uysal T. Do enamel microabrasion and casein phosphopeptide-amorphous calcium phosphate affect shear bond strength of orthodontic brackets bonded to a demineralized enamel surface? Angle Orthod 2012; 82: 36–41.

27. Uysal T, Baysal A, Uysal B, Aydinbelge M, Al-Qunaian T. Do fluoride and casein phosphopeptide-amorphous calcium phosphate affect shear bond strength of orthodontic brackets bonded to a demineralized enamel surface? Angle Orthod 2011; 81: 490–5.

28. Xiaojun D, Jing L, Xuehua G, Hong R, Youcheng Y, Zhangyu G, *et al*. Effects of CPP-ACP paste on the shear bond strength of orthodontic brackets. Angle Orthod 2009; 79: 945–50.

29. Keçik D, Cehreli SB, Sar C, Unver B. Effect of acidulated phosphate fluoride and casein phosphopeptide-amorphous calcium phosphate application on shear bond strength of orthodontic brackets. Angle Orthod 2008; 78: 129–33.

Table 1: Mean SBS values (MPa) and descriptive statistics

Group	Mean	SD	Minimum	Maximum	n	Scheffé*
I (Control)	**13.5**	3.8	4.9	20.8	30	**A,B**
II (Clinpro XT Varnish)	**15.7**	3.4	11.0	26.2	30	**A**
III (MI Paste Plus)	**15.8**	4.2	8.7	29.0	30	**A**
IV (Fluor Protector)	**11.0**	3.8	5.3	19.3	30	**B**

*Scheffé post-hoc multiple comparisons (1-way ANOVA); $p = 0.05$. Groups with different letters are significantly different from each other.

Table 2: Distribution frequency and percentages of ARI scores

	ARI score (%)					
Group	**0**	**1**	**2**	**3**	**n**	**EF**
I	5 (16.6)	8 (27)	1 (3)	16 (53)	30	0
II	0 (0)	25 (83.3)	5 (16.6)	0 (0)	30	0
III	3 (10)	7 (23.3)	19 (63.3)	1 (3.3)	30	0
IV	1 (3.3)	3 (1.0)	0 (8.0)	26 (86.6)	30	0

$X^2 = 113.75$; df = 9; p .000.
ARI= Adhesive Remnant Index
EF= Enamel Fracture