ORIGINAL ARTICLE

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

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ABSTRACT

Objective: *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 four 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 three 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 IV, Fluor Protector. The samples were stored (37°C, 24 hours) and debonded with a universal testing machine. The adhesive remnant index (ARI) including enamel fracture score was also evaluated.*

Results: *The SBS values of 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). The ARI in the Group II showed the lowest amount of adhesive remaining and the largest amount of adhesive was shown by the 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: Enamel, orthodontic brackets, remineralizing, shear bond strength

INTRODUCTION

The remineralizing agents are of great importance in the field of orthodontics, as during an orthodontic treatment, it is more difficult to make a good hygiene control. 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).

The 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 the food intake, specifically carbohydrates (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 and permanent teething (15, 16).

The presence of such injuries during the 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 the treatment, and its presence can be detected four weeks after placement of fixed appliances orthodontic (17).

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

MATERIALS AND METHODS

Shear bond strength

Teeth

A total of 120 human premolars extracted for orthodontic reasons were stored in a thymol solution 0.1% (wt/vol). The study was approved by the School of Dentistry/ Ethics Committee, University State of Mexico. 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 (0.018", Alexander Signature Ormco Corp, Orange, CA, USA) 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, CA, USA), resin was applied to the bracket base for cementation, then light cured for 6 seconds with a Ortholux lamp (3M Unitek Monrovia, CA, USA).

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 for 3 minutes.

Group IV (experimental): Fluor Protector (Ivoclar Vivadent). It was carried out the same procedure in the control group. However, using the 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 an 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 hours (20).

Shear bond strength 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 Scheffé test (one-way analysis of variance) was applied with predetermined significance at $p < 0.05$.

Adhesive remnant index

Once the SBS test was evaluated to assess the amount of residual adhesive on the surface of the teeth, according to the original score of adhesive remnant index (ARI). The Chi-square test was used to analyse the ARI.

RESULTS

Shear bond strength

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

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 the 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 a 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 healthcare in helping to remineralize teeth. The casein phosphopeptide stabilizes the amorphous calcium phosphate in the 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 is an ionomer varnish that provides the dental organ with one of the biggest benefits and is adhering to the tooth structure, release of fluoride, calcium and phosphate potentially to 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 favourable values, which do not affect the SBS, were found. However, the SBS values of the groups II (Clinpro XT Varnish) and III (MI Paste Plus) were significantly higher than the groups I (Control) and IV (Fluor Protector).

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 (one-way ANOVA); $p = 0.05$. Groups with different letters are significantly different from each other.
SD = standard deviation; SBS = shear bond strength.

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

Chi-square = 113.75; df = 9; $p = 0.000$.
ARI = adhesive remnant index; EF = enamel fracture.

Baysal and Uysal (26) found that when performing a microabrasion and remineralization of a previously demineralized enamel, 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) suggested that CPP-ACP pretreatment improves bonding demineralized enamel.

Similar studies, as Xiaojun *et al* (28), have 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, Keçik *et al* (29) reported that pretreatment with CPP-ACP and acidulated phosphate fluoride 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 the SBS. However, it should be considered the limitations of in vitro tests when interpreting the results.

CONCLUSION

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

(1) The application of these remineralizing agents had favourable values that did not affect the SBS and thus orthodontic brackets.

(2) 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.

(3) 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.

(4) Both agents tested in groups II and III showed that, from the ecological point of view, they 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 analyse the real benefits in clinical practice and preventive effects.

AUTHOR'S NOTE

RJS-V provided oversight to study, participated in data interpretation and revision of manuscript, and approved final version. AAN-S oversaw data collection, conducted data analysis, wrote manuscript and approved final version. LER-V participated in study design, data analysis and interpretation, critically revised manuscript and approved final version. RC-B and UV-E participated in study design, interpretation of data and revision of manuscript and approved final version.

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