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Comparing the Effect of Two Different Remineralizing Agents on Shear Bond Strength of Orthodontics Brackets

Research Article

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Abstract

Objective: This study was conducted to evaluate shear bond strength of orthodontic brackets bonded to demineralized enamel, which in turn were pretreated with glass ionomer (Clinpro XT Varnish) modified with resin or resin infiltrate (Icon) of low-viscosity.
Methods: A total of 45 human maxillary premolars were allocated into three groups (n = 15). In all groups, the buccal surfaces were subjected to the cariogenic challenge to initiate white spot lesions. In group I, the lesions were treated with resin infiltrate while, in Group II, the lesions were treated with Clinpro XT Varnish, in Group III the buccal surfaces were untreated which used as control. Transbond XT adhesive system was used and shear bond strength was tested by a universal testing machine. Samples were examined under scanning electron microscopy (SEM) after treatment of enamel surfaces. Statistical analysis was performed by ANOVA tests followed by post-hoc Tukey test.
Results: The two tested groups showed significantly higher shear bond strength than the control group. SEM images revealed that cohesive failure mode and the combination bracket/adhesive interface respectively were more noticeable in group II (Clinpro XT) than in group I (Icon).
Conclusion: Preconditioning of demineralized enamel with resin infiltrate (Icon) or Clinpro XT Varnish did not cause any impairment to the shear bond strength of the orthodontic brackets but rather caused its increase.

Keywords: Orthodontic Brackets; Shear Bond Strength; Resin Infiltrate; ClinproXT Varnish.

Introduction

Orthodontic brackets fixation could enhance plaque retention which favoring the development of enamel demineralization around the orthodontic brackets especially among patients with poor oral hygiene. It is possible that these white spot enamel lesions do not just develop during the orthodontic treatment, but in fact, are found when such treatment starts [1]. Approximately 50% of patients with orthodontics brackets develop initial carious lesions. A significant gradually increasing of carious lesions prevalence and severity during the orthodontic treatment procedure was observed [2-6].

Fluorides are the most common substances used to remineralize white spots or incipient lesions [7]. Fluoride varnishes are known to have longer contact with the enamel when compared to the contact ability of toothpaste, as they tend to adhere to the dental surfaces [8]. This is explained by formation of calcium fluoride ions (CaF+) which are retained on enamel and in dental plaque as intraoral fluoride reservoirs, these ions slowly released at low pH aids inhibiting demineralization procedure [9, 10]. The formation of intraoral CaF+ ions is limited by the availability of calcium and fluoride ions [11]. The anti-cariogenic efficacy and remineralization of early caries lesions can be enhanced when calcium and phosphate ions are applied in combination with fluoride ions [12-14]. Many manufacturers modified fluoride varnishes to include calcium and phosphate ions in an attempt for further improve efficacy. One of recent forms of varnishes, is the resin modified glass ionomer (Clinpro XT) varnish which characterized by its remineralizing action resulting from fluoride ions release, moreo-

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ver it acts as a physical barrier which would protect the enamel against acid attack [15].

Over the years, various modalities of treatment were developed aiming to treat white spot lesions and make them less visible [16-19]. These lesions can stabilize by minimally invasive means which involves applying an infiltrating material of low-viscosity into porous enamel and blocking them [20, 21]. Clinical trials [22, 23] showed that the caries progression of infiltrated lesions is significantly reduced. As a result of the stabilization of demineralized enamel, it is reasonable to note that the resin infiltrate could prove to be a beneficial method of pretreatment before orthodontic fixation [24].

Orthodontic brackets bonding and re-bonding are common procedures during orthodontic treatment result in high mechanical and thermal stresses due to the high de-bonding rates of orthodontic brackets, as a due to the high de-bonding rates of orthodontic brackets [25]. During the re-bonding procedure, white spot lesions may be found on teeth surfaces that may affect the adequacy of the re-bonding procedure [24, 26].

The objectives of the present study were: to evaluate the shear bond strength of orthodontic brackets which were bonded to demineralized enamel, which in turn were pretreated with glass ionomer (Clinpro XT Varnish) modified with resin or resin infiltrate (Icon) of low-viscosity and to assess the different failure modes occurred by the means of scanning electron microscopy (SEM).

Materials and Methods

The present study was an in vitro study to evaluate and compare the effect of two different remineralizing agents on the shear bond strength of bonded orthodontic brackets.

Samples selection

Freshly extracted 45 upper premolars due to orthodontic reasons were collected and stored in thymol (0.1% wt/vol). The collected premolars were free from caries and crakes, teeth with restorations were excluded. The teeth were removed from thymol solution, cleaned with a soft brush, prepared for the shear bond strength test.

Sample size calculation

The sample size calculator (https://www.cdc.gov/epiinfo/user-guide.) used a 5% type I error, 0.80 power, and data from the previous study were used for calculations. The calculated size was (43) which increased to (45) to allow equal distribution. A significance level equal to or less than 0.05 was considered significant.

Demineralized Samples preparation

The 45 selected teeth were polished using rubber polishing cup and pumice- fluoride free. After cleaning, teeth were carefully washed under tape water to remove residual pumice. The demineralizing solution comprised of acetic acid (50 mM) solution, 2.2 mM $Ca(NO_3)_2$, 2.2 mM KH_2PO_4. The pH of the solution was then adjusted using sodium hydroxide titrant till reach a pH 4.6 to induce artificial initial carious lesions [27]. The enamel samples were immersed totally in the previously prepared solution for 12 hours allowing formation of the initial carious lesions. Subsequently, the samples were carefully examined for artificial lesions formation then washed using tap water to remove any excess acid.

Application of remineralizing agents

Each tooth was dried carefully the embedded its root in an acrylic resin block up to 1 mm below the cemento-enamel junction. The teeth were painted with acid-resistant varnish (nail varnish). Except for an area of 4 x 4 mm on the buccal surface which was kept free for further applications [28].

The teeth were randomly divided into three equal groups. The sample was divided into three major groups; group I: used (Icon) resin before bonding procedure, group II: used Clinpro XT varnish before bonding, and group III: the control group no remineralizing agent was used.

Group I (Resin infiltrate or Icon)[1]: The enamel surface was etched with 15% hydrochloric acid gel (Icon Etch, DMG) for 2 minutes before rinsing with water for 30 seconds. The surface was dried with ethanol (Icon Dry, DMG), applied for 30 seconds. With a sponge applicator, the low-viscosity infiltrate resin (Icon Infiltrate, DMG) was applied to the surface for 3 minutes. The infiltrate was light-cured for 40 seconds at 800 W/cm^2 (Bluephase, Ivoclar Vivadent; Schaan, Liechtenstein). After light curing, the infiltrate was applied again for 1 minute and light-cured for 40 seconds.

Group II (Clinpro XT varnish)[2]: Teeth were cleaned then washed with water and dried for five seconds, teeth surfaces were treated with Phosphoric acid 35 % for 15 seconds and then washed and dried. Clinpro XT varnish durable fluoride-releasing coat, one click from the varnish was mixed for 15 seconds, then applied and light-cured for 20 seconds.

Group III (Control group): Teeth were kept with no application of any remineralizing agents.

Bonding the orthodontic brackets

To ensure standardization, one examiner was trained and calibrated for all steps. All the teeth in the three groups were etched using 35% phosphoric acid gel for 30 seconds then washed with water. The teeth were dries gently using air blowing then,Transbond XT system (3M Unitek, Landsberg, Germany) was applied following the manufacturer's instructions. (45) steel brackets with retentive mesh base (12.9 mm^2) for upper premolars were selected and bonded to the teeth. The Transbond XT adhesive was applied to the base the bracket and at the enamel surface. A contact pressure of 300 g was applied to the center of the bracket for three seconds according to the manufacturer's recommendations.

Shear bond strength test

Each tooth was placed in the Universal testing machine within half an hour from the initial bonding. An occluso-gingival load was applied, so that the treated surface was parallel to the shearing rod of the universal testing machine (Zwick GmbH & Co, Ulm, Germany). The load was applied at a cross-head speed of 1 mm/min. A computer connected to the universal test machine

was recorded the results of each test electronically in Megapascals (Mps).

Failure mode analysis of the deboned teeth was recorded by one examiner who was calibrated to each failure mode criteria and blinded to the type of bonding. Each tooth and the bracket base were visuallyinspected under low power magnification (X40) using a light microscope. The failure sites were divided into: adhesive failure = enamel/bonding interface (0-25% of the bonding left on the tooth); cohesive failure,within the bonding materials (25-75% of the bonding left on the tooth), and combination bracket/adhesive interface (75- 100% of the bonding left on the tooth) [29].

Scanning electron microscope evaluation:

The specimens were gently air-dried, dehydrated in ascending grades of ethanol (35%, 50%, 75%, 95%, 100%) then dried to the critical points by immersion of the dehydrated samples in 1-2 ml of hexamethyldisilazane (HMDS) for 10 minutes. Decantation of the HMDS from the sample vial was carried out,then the sample vial was left with the other samples in a desiccator to air-dry overnight at room temperature to minimize the specimen distortion. The types of failure modes after brackets debonding were examined by the scanning electron microscope at X2000 magnification. Failure mode scores ranged from 0 to 3, as follows: 0 = no bond was left on the enamel surface; 1 = less than half of the bond was left on the enamel; 2 = half or more of the bond was left on the enamel, and 3 = all of the bonds were left on the enamel.

Statistical analysis

Data was collected, tabulated and then analyzed using SPSS version 20. Descriptive display for all data was performed, comparing between the samples shear bond strength, ANOVA tests with Tukey post hoc tests were used. The comparison between the frequencies of failures between the groups was tested using a chi-square test. p-value of less than 0.05 was considered significant.

Results

Shear bond strength

Table (1) shows the mean values of shear bond strength of the three groups, Clinpro XT group showed the highest mean value (23.08) followed by the Icon group (22.91), with no significant difference between them (p = 0.07) (table 2). The Control group showed the lowest significant mean shear bond strength value (17.94) compared by Tukey test with Clinpro XT and Icon groups (p = 0.000) (table 2). Statistical significance difference was found between the three groups tested by ANOVA test (p = 0.000).

Failure mode

Regarding the failure mode, the control group showed the higher frequency of adhesive failure mode (73.3%), while the Clinpro XT group showed the lowest frequency (13.3%) with a significant difference between the three groups tested by the chi-square test. Regarding the cohesive and combination failure modes, the Clinpro XT group showed the highest frequencies (66.7% and 20% respectively), while the control group expressed the lowest frequencies (20% and 6.7% respectively). Significant differences between the three groups regarding the cohesive and combination failure modes were found (p=0.000). Table (3)

SEM observation

The failure mode of the two tested materials using a scanning electron microscope was shown in photomicrographs (1-3). Photomicrographs (1,2) showed that group II (Clinpro XT) revealed that the cohesive failure mode and the combination bracket/adhesive interface respectively, were more noticeable than in group I (Icon). However, photomicrograph (3) revealed that the adhesive failure mode was more apparent in group I than in group II.

Discussion

This was an in-vitro study conducted on human maxillary premo-

Table 1. Comparing between the mean values of shear bond strength (Mps) for the three groups.

Groups	Mean	SD	Minimum	Maximum
GI (Icon)	22.91	4.06	18.85	24.11
GII (Clinpro XT)	23.08	3.15	20.54	26.21
GIII (Control)	17.94	5.33	15.91	20.17
ANOVA test	12.539			
P value	0.000*			

SD: Standard deviation
*: significant at p level less than 0.05

Table 2. Post hoc comparison between the three groups by Tukey test.

Groups	P value
GI versus GII	0.07
GI versus GIII	0.000*
GII versus GIII	0.000*

Table 3. Frequencies of failure mode of the bonding system among the three groups.

	Adhesive N (%)	Cohesive N (%)	Combination N (%)	X^2 (p)
GI (Icon)	8 (53.3%)	5 (33.3%)	2 (13.3%)	16.593 (0.000)*
GII (Clinpro XT)	2 (13.3%)	10 (66.7%)	3 (20%)	21.706 (0.000)*
GIII (Control)	11 (73.3%)	3 (20%)	1(6.7%)	33.218 (0.000)*
X^2 (p)	18.641 (0.000)*	11.983 (0.000)*	8.499 (0.000)*	

X^2: Chi square test values
*: significant at p level less than 0.05

Figure 1. SEM micrograph showing cohesive failure mode in group II & group I (X2000).

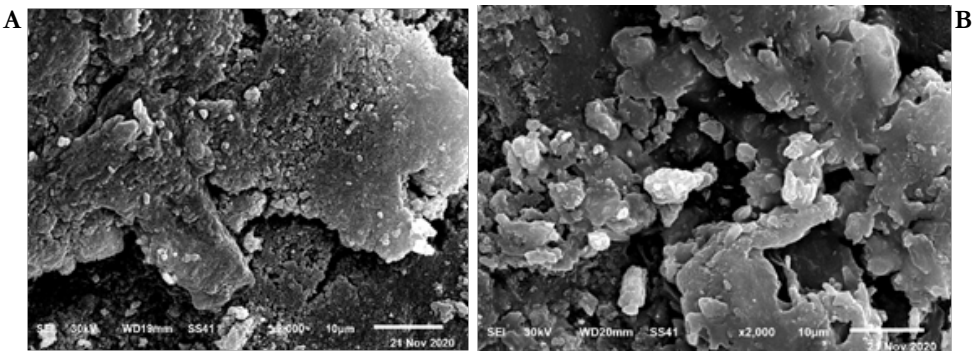


Figure 2. SEM micrograph showing combination bracket/adhesive interface in group II & group I (X2000).

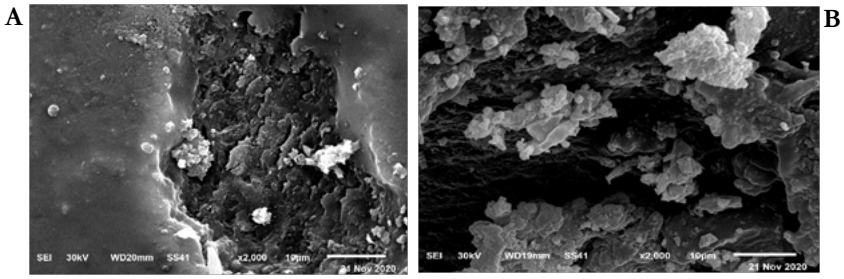
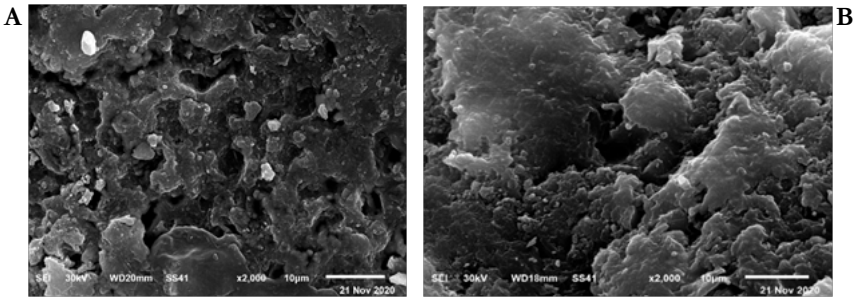


Figure 3. SEM micrograph showing adhesive failure = enamel/bonding interface in group II & group I (X2000).



lars which were selected as enamel substrate and artificial incipient caries lesions with low variability and histologic characteristics resembling those of natural lesions were created [30, 31].

Clinpro XT Varnish durable fluoride is an ionomer varnish which can be utilized in the prevention and treatment of white spot lesions, dentinal hypersensitivity and is useful for application around orthodontic appliances [32, 3]. Nonetheless, this product might not resolve the esthetic problem of white spot lesions on the labial surface of teeth. Icon resin is a very low viscosity resin, with refractive optical properties similar to those of healthy enamel which indicated for esthetic improvement and remineralization of incipient caries, with color stability up to 12 months [35]. Its effectiveness in stopping the progression of non-cavitated caries might continue to more than three years after its application [20].

The present study revealed that the Clinpro XT varnish group showed the highest mean value of shear bond strength followed by the Icon resin group with no significant difference between them (p = 0.07) (Table1,2). These results can be explained in different ways, the use of adhesive containing primer with monomer (triethylene glycol dimethacrylate) and (2-hydroxyethyl methacrylate) content which have a high penetration capability that allows the chemical connection of the resin infiltrate to the primer [36, 37]. Another explanation, that the primer may partially penetrate into the demineralized enamel and strengthen the outermost part of the Icon infiltration enamel when it is applied after preconditioning resulting in higher shear bond strength [24].

The results of the present study are inconsistent with the previ-

ous studies which found a significant increase in the shear bond strength of Transbond XT adhesive when Icon resin was applied before bonding orthodontic brackets to sound enamel or demineralized enamel [38, 39]. In general, bond strength was not impaired rather than enhanced by Icon infiltrate preconditioning. [24, 39].

Moreover, the present results are in accordance with previous study results, by Vianna et al, 2016 [40] who evaluated the shear bond strength of orthodontic brackets which were bonded to demineralized enamel, which in turn were pretreated with glass ionomer (Clinpro XT Varnish) modified with resin or resin infiltrate (Icon) of low-viscosity, the results revealed that all tested groups presented shear bond strengths similar to or higher than the control group.

Another relevant finding besides shear bond strength is the failure mode upon debonding of the brackets. The predominant finding regarding the failure mode was shown in Table 3 which revealed that the Clinpro XT varnish group showed the lowest frequency of adhesive mode and the highest frequency of the cohesive and combination failure modes as compared to the other two groups. These findings were shown in the SEM Figures (1-3), in the Icon resin group, showed more adhesive remnants tended to be more frequent on the enamel surface, while in Clinpro XT varnish group express less adhesive remnant tended to be seen left on the enamel surface after de-bonding. This could be attributed to the chemical bond between the resin infiltrate and the adhesive resin.

Conclusion

Preconditioning of demineralized enamel with Icon resin infiltrate or Clinpro XT durable fluoride varnish did not result in the impairment of the shear bond strength of the orthodontic brackets, but rather in its increase. Nonetheless, the results of this study should be extrapolated to clinical practice with cautious consideration, as this is a laboratory study, and further clinical researches are recommended in order to confirm these findings.

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