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Effect of Resin Infiltrant Pretreatment on Shear Bond Strength of Metal Orthodontic Brackets in Vitro Study

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Abstract

Background:

The primary purpose of this study is to determine the effect of Caries resin Infiltrant (Icon) on the shear bond strength of metal orthodontic brackets using three adhesive systems.

Materials and methods:

Sixty-six extracted sound upper first premolars tooth were selected. The collected teeth were divided equally into three groups: Gren gloo, (Italy), Light bond, (USA) and Enlight (Italy). Each one contains twenty-two teeth, which were bonded using the bonding adhesive. Half of them were manipulated with ICON and half of them without ICON. Statistical analysis was performed including t-test, ANOVA test and Tukey's HSD test.

Result:

After comparison among all groups with ICON, all groups (Gren gloo vs. Light bond, Gren gloo vs. Enlight & Light bond vs. Enlight) had a significant difference. After comparison among all groups without ICON, two of them had a significant difference which was (Gren gloo vs. Light bond & Light bond vs. Enlight) while the other group (Gren gloo vs. Enlight) showed a non-significant difference.

Conclusion:

The application of the caries infiltrant following 37% phosphoric acid etching on sound enamel prior to orthodontic bonding could be an alternative to be used as an additional preventive measure against WSL formation. It was concluded that the surface infiltrated by Icon (DMG) did not interfere negatively on the bond strength to the resin composite.

Keywords: Bond strength, Metal orthodontic bracket, ICON, Caries resin Infiltrant

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Introduction

Although the wide benefit of using fixed orthodontic appliance, it can cause unwanted complications if adequate care is not taken into consideration during the treatment. The irregular surfaces of brackets, bands, wires and other attachments limit naturally occurring self-cleansing mechanisms, such as the movement of the oral musculature and saliva [1,2,3].

The use of fixed orthodontic appliances creates plaque accumulation areas and makes tooth cleaning more difficult[4,5].Enamel demineralization around the brackets is one adverse side effect of major clinical relevance [2,5,6,7, 8].

The pH of dental surfaces becomes acidic [9]. The Streptococcus mutans (MS) and Lactobacillus (LS) populations in the plaque over the tooth surface increase and these microorganisms can cause enamel demineralization via organic acid production in the plaque [10 ,11]. The WSLs developed significantly more often in orthodontic patients and these lesions might present severe esthetic problems in the following years [12]. The prevalence of WSLs among orthodontic patients ranges from 2% to 96% [2, 3, 13, 14, 15].

Recently, caries infiltration technique has been used as a promising therapeutic method for non-cavitated lesions. The enamel pores system is filled or reinforced with low-viscosity a light-curable resin [16]. When the pores enamel has been infiltrated by the infiltrating resin and there is a need for an adhesive procedure such as bonding orthodontic brackets; it is unclear whether the bond strength to the pretreated enamel surface would be affected. Moreover, the compatibility of this material to the current bond systems is still unknown [17, 18].

The primary purpose of this study is to determine the effect of caries resin infiltrant (Icon) on shear bond strength of metal orthodontic brackets using three current adhesive systems.

Materials & Methods

Eighty freshly extracted sound human upper first premolars were collected from patients seeking orthodontic treatment and rinsed with water [19 and 20], then stored in closed container containing 0.9% sodium chloride (normal saline) with 0.1% thymol to prevent dehydration and bacterial growth which change weekly, at room temperature till the testing date [21, 25]. Sixty-six extracted teeth were selected after being examined with 10X magnifying lens to exclude any specimen having cracks or any other deformities in enamel surfaces that will be tested in present study [21]. The selected teeth were caries free, no enamel cracks or restorations and no surface irregularities or marked structural or developmental anomalies. The collected teeth were divided equally into three groups as follows:

1-First group

This group contains twenty-two sound upper first premolars which were bonded using the bonding adhesive. (Gren gloo, Italy) Half of them were pretreated with ICON and half of them without ICON.

2-Second group

This group contains twenty-two sound upper first premolars which were bonded using the bonding adhesive. (Light bond, USA) Half of them were pretreated with ICON and half of them without ICON.

3-Third group

This contains twenty-two sound upper first premolars which were bonded using the bonding adhesive. (Enlight, Italy) Half of them were pretreated with ICON and half of them without ICON.

The half of number of each specimen in each group, the caries resin infiltrant was applied. The Icon was applied on the buccal surface of sound upper premolars, followed by the application of the adhesive material.

While the other half of each specimen in each group the application of the adhesive material was without ICON.

The roots of the teeth were serrated by diamond disk, made a retentive wedge-shaped to increase the retention of the teeth inside the self-cured acrylic blocks two teeth were fixed with 2cm apart [26,27] and adjusted vertically using the surveyor (Dentaurum, Germany), the O ring mold (3 cm, 3 cm). The powder and liquid of the self-curing acrylic resin (Vertex, Netherland) were then mixed according to the manufacturer's instructions and poured around the teeth to the level of cemento-enamel junction [28,29]. After setting has been completed, the excess material has been removed and polished by pumic paste without fluoride.

The buccal surface of the teeth was cleaned with a rubber cup (Full Dent Prophy Cups, Switzerland) and non-fluoridated pumice for 10 s. [30, 31].The teeth were then washed using running water for 10 s. and dried with oil-free steam of air for another 10 s. This procedure was set to simulate the 'real life' clinical situation [29,32].

A 37% phosphoric acid etching gel (Ivoclar, Vivadent) was applied on the buccal surface of the crowns for 30 s. and then washed with air/water spray and dried with oil-free steam of air until the buccal surface of the etched enamel appeared chalky white [33, 34].

A thin layer of light activated orthodontic adhesive paste (Gren gloo, Lightbond, Enlight) was applied to the Stainless steel orthodontic brackets (0.022 ×0.030 inch standard edge wise, Pinaccle, coarse mesh base with surface area = 11.7 mm2. Ortho Technology, USA) [35], which was then placed onto the buccal surface of the tooth surface at the middle of the middle third of the buccal surface [24]. Any excess adhesive was removed gently from around the base of the bracket using dental probe before setting without disturbing the seated bracket [36 , 40]. The adhesive material was cured for 40 s. [41, 42] using LED light cure unit with wavelength range 400-500 nm and light intensity more than 500mW /cm2 (WOODPECKER Co., CHINA). Where 10 s. curing time was set for each of the four directions; mesial, distal, occlusal and cervical. The adjacent teeth were covered with opaque rings before curing to prevent the effect of the disseminated light [43]. After the completion of the bonding procedure, the teeth were stored in a patch containing normal saline solution with 0.1% thymol until testing procedure [22].

For the half of specimen in each group, the Icon-Etch was applied, set for 2 m, then rinsed off with water for 30 sec., dry with oil and water-free air, apply Icon-dry, let sit for 30 s. and thereby carry out visual inspection then dry with oil and water-free air. Applying Icon, let it set for 3 m, dispensed with air & light cure for 40 s. Applying Icon-Infiltrant, let sit for 1 min, remove excess then light cure for 40 sec. (according to the manufacturer's instructions).

After that, a light-activation orthodontic adhesive paste (Gren gloo, Light bond, Enlight) was applied to the bracket base according to the instructional steps for each type and bonded over the coated layer as described previously. Then the teeth were stored in a patch containing normal saline solution with 0.1% thymol until bonding procedure [22].

Shear bond strength test was done 24 hours after bonding procedure to allow for complete polymerization of adhesive [29,44,45].The Shear bond strength testing was carried out using Tinius-Olsen Universal testing machine with a 5KN load cell, A custom made chisel rod as crosshead speed of 0.5mm/min [46]. Each specimen was placed in the machine base parallel to the horizontal plane. The chisel-end rod was fitted inside the upper arm of the testing machine, parallel to the middle third of the buccal surface of the tooth and perpendicular to the enamel/ bracket interface. This was done to provide a force in an occluso-gingival direction [47, 48].

The highest magnitude of the load values was considered as the load of the bond failure. The failure load (in Newton) was divided by the base bonding area (11.7 mm2 in the study) to calculate the shear bond strength in MPa (N/mm2).

Results

Statistical Analysis

Statistical analysis was performed by SPSS program version 21. Descriptive statistics including mean and standard deviations were performed for each experimental group and the statistical analysis was performed by using:

1-Inferential statistics included independent sample t-test was done for comparison between different groups.

2-ANOVA test.

3-Tukey's HSD test.

Descriptive statistics of shear bond strength (MPa) and the effect of ICON application on the shear strength of adhesive from different companies were calculated.

T-test showed that the mean value of the shear bond strength was significantly higher in the group that using ICON as compared with the other group that didn't use ICON for the same (Enlight) company. Also, the mean value of the shear bond strength was higher (despite its non-significant) in the group that was using ICON as compared with the other group that didn't use ICON for the same (Gren gloo) company. But the (Light bond) company showed that the result was higher for the group without ICON as compared with other group using ICON as shown in (Table 1).

Materials	State	Descriptive statistics			Comparison	
		N	Mean	S.D.	t-test	p-value
Gren gloo	with ICON	11	8.16	0.73	0.927	0.365
	without ICON	11	7.79	1.10		
Light bond	with ICON	11	4.49	1.05	-11.368	0.000***
	without ICON	11	10.88	1.54		
Enlight	with ICON	11	11.84	1.11	11.755	0.000***
	without ICON	11	7.29	0.64		

Table 1: Descriptive statistics of shear bond strength (MPa) and the effect of ICON application on the shear strength of adhesive from different companies.

Descriptive statistics and comparison the shear bond strength of adhesive of different companies in case application and without application of ICON were calculated. After comparison between all groups with ICON by using F-test, all groups (Gren gloo vs. Light bond, Gren gloo vs. Enlight & Light bond vs. Enlight) had a significant difference. And after comparison between all groups without ICON by using F-test, two of the groups had a significant difference which was (Gren gloo vs. Light bond & Light bond vs. Enlight) while the other group (Gren gloo vs. Enlight) showed a non-significant difference (Table 2).

State	Materials	Descriptive statistics			Comparison			
					ANOVA		Tukey's HSD	
		N	Mean	S.D.	F-test	p-value	Groups	p-value
With ICON	Gren gloo	11	8.16	0.73	155.645	0.000***	Gren gloo vs. Light bond	0.000***
	Light bond	11	4.49	1.05			Gren gloo vs. Enlight	0.000***
	Enlight	11	11.84	1.11			Light bond vs. Enlight	0.000***
Without ICON	Gren gloo	11	7.79	1.10	31.133	0.000***	Gren gloo vs. Light bond	0.000***
	Light bond	11	10.88	1.54			Gren gloo vs. Enlight	0.578
	Enlight	11	7.29	0.64			Light bond vs. Enlight	0.000***

Table 2: Descriptive statistics and comparison of shear bond strength (MPa) of adhesive from different companies in case of application and without application of ICON.

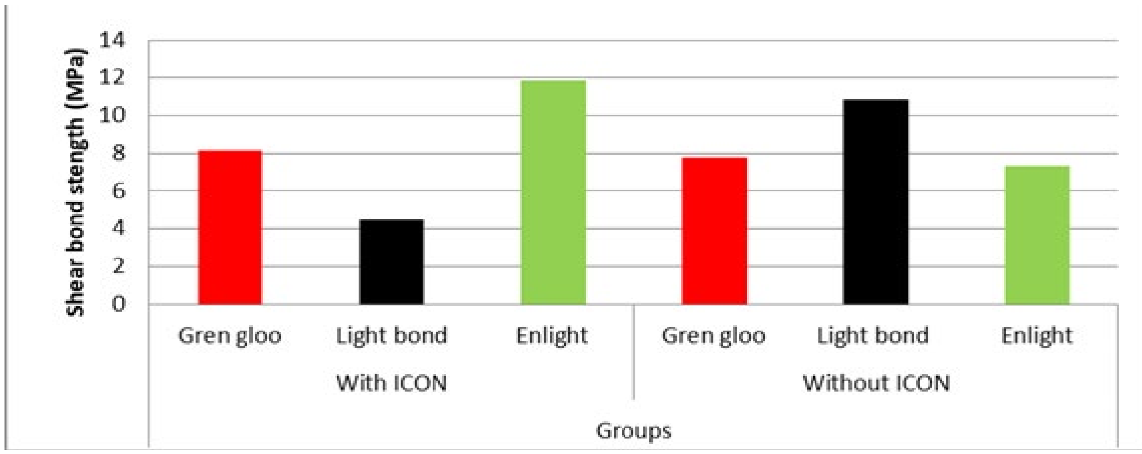

Fig.3: Shear bond strength (MPa) of adhesive from different companies in case of application and without application of ICON.

Discussion

In this in vitro study, with the exception of light bond with (ICON, DMG) group and the reason behind the reduction in shear bond strength in this group may be attributed to the chemical bond between the ICON and light bond adhesive. However, it's not reflecting the different bond strength at different interfaces. Therefore, this may be related to other factors such as the composition of the resin material, filler size, time of light cure exposure and stored medium. [65] All other groups had a shear bond strength exceeding the minimum limits which is 6-8 MPa; to be able to withstand masticatory and orthodontic forces, which would be adequate for most clinical orthodontic needs [49 ,53].

In previous studies, the remineralization actions with highly concentrated fluorides, similar to the ones found in commercial mouth rinses, were observed and had proven to prevent the incipient carious lesion progression. Nonetheless, this remineralization seems to be superficial. The internal portion of the enamel lesion is more susceptible to demineralization as a result of the gradient on the enamel solubility, with the internal enamel being more soluble compared to the enamel external portion [54, 55].

The group infiltrated with the infiltrant resin (ICON, DMG) was higher than to the control group, probably as a result of the affinity between the resin infiltrant monomer (ICON, DMG) and the resin monomers from the adhesive system for the evaluated adhesive systems. These results are agreed with Wiegand that reported the usage of a caries infiltrant material before the conventional adhesive application does not interfere with the bond [56, 57]. Therefore, it can be noticed that the usage of an infiltrant material before the adhesive system application does not interfere with the bond strength to the enamel. Overall, the bond strength was not impaired, but rather it was enhanced by caries infiltrant preconditioning, confirming the results of previous studies [58, 59].

One important prerequisite in sealing enamel is the high surface wettability property of the applied resins.[60] High TEGDMA content and ethanol in adhesives were shown to increase the capillary penetration and wetting ability of the resins facilitating better micro-mechanical unity with the enamel, whereas Bis-GMA content decreases this property, which might result in weakened plugging of the porosities.[61,62, 63] On the other hand, the high TEGDMA content in the resin matrix increases polymerization shrinkage and stress resulting in lower physical properties. Similarly, more oxygen inhibition and polymerization shrinkage of the low-viscosity caries infiltrant was reported to create heterogeneous areas within the penetrated material, resulting in insufficiently filled porosities of the surface.[63, 64] In that respect, Icon with the highest TEGDMA content among the tested resins was expected to provide better penetration into the enamel with the higher contact area. In addition, voids in sealed surface due to the oxygen inhibition and polymerization shrinkage were anticipated.

According to the results, the adhesive treatment can be applied to the treated surface with the resin-based infiltrant material (ICON– DMG), which does not negatively interfere with the bond between resin composite and enamel, it showed to be statistically superior to the other groups which didn't use resin-based infiltrant material (ICON–DMG).

Conclusion

The surface infiltrated by ICON (DMG) did not interfere negatively on the bond strength to the resin composite. The application of the caries infiltrant following 37% phosphoric acid etching on sound enamel prior to orthodontic bonding could be an alternative to be used as an additional preventive measure against WSL formation. According to the present result, the Icon-caries infiltrant indicated booth for patients have been previously treated with fixed orthodontic treatment or to patients have white spot treated previously with Icon.

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