The Effect of Enamel Protective Agent on Shear and Tensile Bond Strength of Stainless Steel Brackets by Using Different Adhesive Agents (*In Vitro* Study)

Dhuha Abdul-Qader, B.D.S. [(a)]
Sami K. Al-Joubori, B.D.S., M.Sc. [(b)]

ABSTRACT

Background: Decalcification of enamel surface adjacent to fixed orthodontic appliances, in the form of white spot lesions, is a wide spread and familiar well-known side effect of orthodontic treatment. The present study was carried out to evaluate the effect of enamel protective agent (Clinpro white varnish) on shear and tensile bond strength of Dentaurum orthodontic stainless steel brackets by using 3M Unitek and Ormco as orthodontic adhesive agents.

Materials and methods: Sixty-four extracted human upper first premolar teeth were selected and randomly divided into two groups with 32 teeth each, representing the shear and tensile bond strength testing groups. Then according to the type of bonding adhesive and the addition of Clinpro before bonding (3M, Clinpro + 3M, Ormco, Clinpro + Ormco) each group was subdivided into four equal subgroups each with 8 teeth. After passing twenty-four hours of bonding procedure, where the samples were kept at 37˚C the brackets were debonded by using Tinius-Olsen universal testing machine to record the shear and tensile bond strength value. The difference in bond strength was analyzed by using ANOVA test at $p \leq 0.05$.

Results: The use of Clinpro with 3M Unitek orthodontic bonding agent shows higher shear and tensile bond strength than Clinpro with Ormco orthodontic bonding agent.

Conclusions: Using Clinpro white varnish before bonding can be successfully used with 3M Unitek orthodontic bonding agent.

Keywords: Clinpro white varnish, bond strength, 3M and Ormco orthodontic bonding agent. **(J Bagh Coll Dentistry 2017; 29(3):75-79)**

INTRODUCTION

The fixation of orthodontic brackets enhances plaque retention and when the oral hygiene of the patient is poor, this will favor the development of demineralization and initial caries around the brackets [(1)].

As carbohydrates been taken daily, they are fermented by the bacteria that colonized in the plaque and lead to decrease the intraoral pH. The low pH results in dissociation of calcium and phosphate ions from the enamel in an attempt to reach chemical equilibrium in the oral cavity environment. Thus, one possible inseparable problem during the whole course of orthodontic treatment is the enamel demineralization around brackets, representing the primary phase of caries formation [(2)].

Prevalence of these acquired surface lesions due to orthodontic treatment, white spot lesions (WSL) is relatively high, affecting more than 40% to 60% of the orthodontic patients. They can appear very quickly, as rapid as in a couple of weeks after fixation of the brackets [(3, 4)].

Brackets are bonded to the surface of teeth with orthodontic adhesive. Bonding of orthodontic brackets to the tooth enamel has been an important issue since the introduction of direct bonding in orthodontics [(5)].

Composite resins are one of the most frequently used adhesives in orthodontic bonding [(6)]. Although they provide sufficient bonding strength and are easy to handle, they adhere to the tooth enamel only by micro-retention, require dry field and amount of fluoride release have not been found to be sufficient for anti-caries effect [(7)].

The efficacy of preventive measures against the appearance of this phenomenon has been questioned during the last two decades. Preventive methods mainly target the remineralization process and the inhibition of present bacterial flora through the use of topical fluoride applications, use of adhesives with remineralization potential that contains amorphous calcium phosphate or fluoride, ozone applications, chlorhexidine mouth rinses, probiotics, xylitol, and sealants [(8)].

The Preventive measures that do not require patient compliance are considered more predictable since only 13% of the patients were notified to achieve excellent cooperation with the use of mouth rinses and tooth brushing [(9)].Therefore, sealing the susceptible enamel prior to bracket placing in order to form a caries-protective shield has been the focus of interest in previous studies that primarily intend to obviate patient compliance [(10, 11)].

Fluoride has been proven to be effective in reducing the development of WSLs associated with fixed orthodontic treatment [(12)]. Clinpro, is a fluoridated varnish, has been introduced to the market and supposed to be most beneficial in a

[(a)]Master student, Department of Orthodontics, College of Dentistry, University of Baghdad.
[(b)]Assistant Professor, Department of Orthodontics, College of Dentistry, University of Baghdad.

neutral pH environment. Sealants were suggested as protective enamel agents that do not require patient cooperation [11].

MATERIALS AND METHODS

The sample

After examination with magnifying lens (*10X*) and light transillumination [13], sixty-four freshly extracted human maxillary first premolars (extracted for orthodontic reason) were collected and stored in closed containers filled with distilled water with 0.1% concentration of thymol crystals (Volume/Weight) [14], to prevent dehydration and bacterial growth [15, 16].

The teeth were divided into two groups: one for shear bond testing and the other group for tensile bond testing. Then each group was subdivided equally into 4 subgroups according to the orthodontic adhesive agent and the use of Clinpro (white varnish).

Shear bond group:
A1: 3M bonding agent,
A2: Clinpro with 3M,
B1: Ormco bonding agent,
B2: Clinpro with Ormco.

Tensile bond group:
C1: 3M bonding agent,
C2: Clinpro with 3M,
D1: Ormco bonding agent,
D2: Clinpro with Ormco.

Construction of the acrylic block

By using dental surveyor, the teeth assigned for shear testing were mounted vertically on a glass slide, and the teeth assigned for tensile testing were mounted horizontally [17, 18]. Then the acrylic were poured to the level of the cemento-enamel junction of each tooth [19] using two L-shaped metal plate placed in opposite side to make the mold for the acrylic block. After setting, slight adjustment of the acrylic blocks was made by using a portable engine.

After mounting, the specimens were coded and then stored in normal saline solution containing crystals of thymol to prevent dehydration and bacterial growth until bonding [20].

Bonding procedure

The buccal surface of the teeth was polished using non-fluoridated pumice with a brush (one brush used for each subgroup for standardization attached to a low speed handpiece for 10 seconds [21], then each tooth was rinsed with water spray for 10 seconds, and dried with oil-free air for 10 seconds [19].

The distance of 1cm was used as standardization to hold the air water syringe away from tooth surface [22]. Thirty-two teeth (sixteen for shearing test group and sixteen for tensile test group) were bonded directly without using the enamel protective agent (Clinpro) (A1, B1, C1 and D1). Subgroup A1 + subgroup C1 (control)

The bonding agent was done according to manufacturer instructions and at room temperature (24˚ C) with bracket placement in the middle of the buccal surface of the tooth. For standardization of pressure on the bracket, a constant load was placed on the bracket for 10 seconds [23] (by fixing 200 gm load on the upper part of the vertical arm of the surveyor, and fixing a hard rubber polishing bur in the lower part of the vertical arm of the surveyor and put it in contact with the bonded bracket), to make sure that each bracket was seated under an equal force and to ensure a uniform thickness of the adhesive [24].

Any excess adhesive material around the bracket base was gently removed by using dental probe before it has been set without disturbing the seated bracket [25]. Then curing the bracket adhesive (according to manufacturer instructions), at a distance of 5 mm [26].

The same procedure had been made with the samples of subgroups B1 and D1 using Ormco orthodontic bonding agent.

Clinpro was used with subgroups A2, B2, C2 and D2 before etching the tooth surface according to manufacturer instructions of application. The samples, after application of Clinpro, were immersed in artificial saliva at 37˚C for 24 hours [27].Then the subgroup A2 and subgroup C2 was bonded with 3M bonding agent as we did with the subgroups A1 and C1.The subgroup B2 and subgroup D2 was bonded with Ormco bonding agent as it has been done with the subgroups B1 and D1.

After completion of the bonding procedure, the specimens were immersed in distilled water and stored in the incubator at 37˚C for 24 hours prior to bracket debonding [28].

Shear bond strength test

The shear bond strength test was accomplished using a Tinius-Olsen Universal testing machine with a 5 KN load cell, a custom made chisel rod and a cross head speed of 0.5mm/minute [29], and the maximum load necessary to de-bond the bracket was registered [30].

Tensile bond strength test

Tensile testing was accomplished using the same Universal testing machine by using long orthodontic archwires to pull the bracket in a vertical direction [18].

The readings were in megapascal (MPa) by dividing the force values by the bracket basal area (each 1 MPa equals1 N/mm²) [31].

Statistical analyses

Data were analyzed using SPSS (statistical package of social science) software version 19 by using the following statistics:

A. Descriptive statistics: including mean, standard deviation, minimum, maximum, statistical tables.

B. Inferential statistics: including;

1. **Shapiro-Wilk test:** To Test the normality of distribution of the data.
2. **One way analysis of variance (ANOVA):** To test any statistically significant difference among the tested groups.
3. **Tukey's honestly significant difference test:** To test any statistically significant differences between each 2 groups when ANOVA showed a statistical significant difference.

In the statistical evaluation, the following levels of significance are used:

Non-significant	NS	$P > 0.05$
Significant	S	$0.05 \geq P > 0.01$
Highly significant	HS	$P \leq 0.01$

RESULTS

Testing the normality of data distribution was carried out by using Shapiro-Wilk test, and the results showed that the data was normally distributed within the shear and tensile subgroups (p>0.05).

The descriptive statistics of the shear bond strength subgroups were shown in Table (1).

It was clearly that subgroup A1 (samples with 3M Unitek bonding agent) showed the highest shear bond strength value; while subgroup B2 (samples with Clinpro with Ormco bonding agent) demonstrated the least shear bond strength value among the shear bond subgroups.

ANOVA exhibited there was statistically highly significant difference among the mean values of the shear bond subgroups (P≤0.01).

Table 1: Descriptive statistics of the shear bond strength (MPa) subgroups.

Groups	Descriptive statistics				Comparison (d.f.=31)	
	Mean	S.D.	Min.	Max.	F-test	p-value
A1	14.90	1.93	12.29	17.81	47.345	0.000 (HS)
A2	6.16	1.89	4.08	8.96		
B1	12.02	2.51	9.59	15.38		
B2	4.61	1.51	3.04	7.77		

Testing the mean differences by using Tukey honestly significant difference test showed that there was a high significant difference between the subgroups A1 and A2, B1 and B2, and a significant difference between A1 and B1. Nevertheless, the difference between the subgroups A2 and B2 was not significant; as shown in Table (2).

Table 2: Tukey HDS test of the shear bond strength subgroups.

Groups		Mean difference	p-value
A1	A2	8.74	0.000 (HS)
	B1	2.88	0.035 (S)
A2	B2	1.55	0.417 (NS)
B1	B2	7.42	0.000 (HS)

The descriptive statistics of the tensile bond strength subgroups were shown in table (3). It was clearly obvious that the subgroup C1 (samples with 3M Unitek bonding agent) had shown the highest tensile bond strength value; while subgroup D2 (samples with Clinpro and Ormco bonding agent) presented the least tensile strength value.

ANOVA showed that statistically there was a highly significant difference among the mean values of the tensile bond subgroups (P≤0.01).

Table 3: Descriptive statistics of the tensile bond strength (MPa) subgroups

Groups	Descriptive statistics				Comparison (d.f.=31)	
	Mean	S.D.	Min.	Max.	F-test	p-value
C1	5.11	1.36	3.18	7.19	18.391	0.000 (HS)
C2	4.54	1.51	3.08	7.42		
D1	2.42	1.58	0.51	4.77		
D2	0.87	0.19	0.65	1.15		

Testing the mean differences between the tensile subgroups by using Tukey HDS test revealed statistically that there were non significant differences between the subgroups C1 and C2, D1 and D2; whereas there were high significant differences between the subgroups C1 and D1, C2 and D2 as shown in the Table (4).

Table 4: Tukey HDS test of the tensile subgroups.

Groups		Mean difference	p-value
C1	C2	0.57	0.816 (NS)
	D1	2.69	0.001 (HS)
C2	D2	3.67	0.000 (HS)
D1	D2	1.55	0.099 (NS)

DISSCUSION

In this study, the mean SBS of the two orthodontic adhesives; 3M Unitek (14.90 MPa) and Ormco (12.02 MPa) bonding agents was higher than the clinically adequate SBS (5.9 to 7.8 MPa) as proposed by Reynolds [(32)], which means that both of the adhesives can resist shear stress to adequate level.

In addition to that, 3M Unitek orthodontic bonding adhesive gave a greater value in shear test than Ormco orthodontic bonding adhesive, and this could be attributed to the composition of the adhesive including the type, shape, size, and amount of inorganic fillers, and the type of coupling agent present in the adhesive itself [(33)].

While, after the pretreatment with the enamel protective agent (Clinpro), the mean SBS of the 3M Unitek bonding agent (6.16 MPa) was higher than the mean SBS of the Ormco (4.61 MPa) bonding agent, although both of them were higher than the required minimum SBS for direct bonding (3 MPa) suggested by Lopez [(34)].

The mean SBS of the Ormco bonding agent with the pretreatment with Clinpro (4.61 MPa) was lower than that of the control subgroup, and this could be attributed to the resistance effect that the outer enamel layer acquires from the fluoride content of the Clinpro which may be of significant effect [(35)].

The result of the present study showed that the mean tensile bond strength of the 3M Unitek bonding agent (5.11 MPa) was higher than the mean tensile bond strength of the Ormco bonding agent (2.42 MPa).

The findings of the present study showed with the pretreatment of the samples with the enamel protective agent (Clinpro), the mean tensile bond strength of the 3M Unitek bonding agent (4.54 MPa) was higher than the mean tensile bond strength of the Ormco bonding agent (0.87 MPa) and this might be due to the more flowable acid etch of the Ormco orthodontic bonding agent that might have a less penetrating effect than the gel acid etch of the 3M Unitek orthodontic bonding agent, but both of the mean tensile bond strength values were lower than their corresponding control groups [(36)].

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تأثير المادة الواقية لمينا السن على قوى القص والشد باختلاف مواد لصق الحاصرات المعدنية المقاومة للصدأ (دراسة مختبرية)

الخلاصة

زوال كلس المينا لسطوح الاسنان المجاورة لأجهزة تقويم الأسنان الثابتة، في شكل بقع بيضاء، من الاثار الجانبية المعروفة والمألوفة التي تصاحب علاج الاسنان باستخدام التقويم. لقد أجريت هذه الدراسة لتقييم تأثير عامل وقائي المينا (Clinpro) على قوة القص والشد لحاصرات التقويم المعدنية باستخدام مواد لصق حاصرات التقويم (3M)و (Ormco) .

تم اختيار أربعة وستين سن من الضواحك العلوية الأولى من الاسنان البشرية وقسمت عشوائيا إلى مجموعتين 32 سن لكل منهما، تمثل مجموعات اختبار قوة القص وقوة الشد, ثم وفقا لنوع المادة اللاصقة وإضافة عامل واقي المينا (Clinpro) (3M، Clinpro + 3M، Ormco، Clinpro + Ormco) تم تقسيم كل مجموعة إلى أربع مجموعات فرعية متساوية لكل منها 8 أسنان. بعد مرور أربع وعشرين ساعة من إجراء الربط، حيث تم حفظ العينات في 37°C تم اختبار فك الارتباط باستخدام الة الفحص العالمية (Tinius-Olsen) لقياس قيمة قوة القص والشد للحاصرات المعدنية.

تم تحليل الفرق في القوى باستخدام اختبار (ANOVA) ل ($p \leq 0.05$).

كشفت الحقائق من هذه الدراسة أن استخدام (3M UNITEK) كمادة رابطة لحاصرات التقويم يظهر أعلى قوة قص وقوة شد للحاصرات المعدنية، بينما يظهراستخدام واقي المينا (Clinpro) مع مادة لصق الحاصرات (Ormco) أدنى قوة قص وقوة شد لحاصرات التقويم المعدنية.

الخلاصة: باستخدام واقي المينا (Clinpro) قبل مادة لصق حاصرات التقويم المعدنية, يمكن أن تستخدم بنجاح مع (3M UNITEK) كمادة لصق حاصرات تقويم الأسنان.