

## Evaluation of shear bond strength of brackets bonded to fluoride-treated enamel surfaces: An in vitro study

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### ABSTRACT

Enamel decalcification is a well-recognized problem associated with orthodontic treatment with fixed multibanded appliances. Several methods have been proposed to minimize the incidence and severity of white spot decalcification around brackets. The present study is concerned with the evaluation of the effect of different topical fluoride gels, applied before and after etching on the shear bond strength of directly bonded orthodontic brackets. The sample consisted of (70) human upper first premolars distributed to (7) groups: group A served as a control; groups B1, C1, and D1 received, for (4) minutes prior to etching, a topical application of neutral sodium fluoride gel (1.1%), sodium monofluorophosphate gel (1.2%), and acidulated phosphate fluoride gel (1.23%) respectively. Groups B2, C2, and D2, on the other hand, were treated, for (4) minutes after etching, with topical application of neutral sodium fluoride gel (1.1 %), sodium monofluorophosphate fluoride gel (1.2%), and acidulated phosphate fluoride gel (1.23%) respectively.

The brackets were loaded under shear to failure using Universal Compression Machine Apparatus. The shear strengths were recorded in Megapascals.

The results of the present study showed that the application of fluoride gels for (4) minutes before and after etching did not alter the shear bond strengths of directly bonded orthodontic brackets, when compared with the control group, for all groups except for group D2 in which the topical application of acidulated phosphate fluoride gel for (4) minutes after etching has resulted in a significant reduction in shear bond strength and severity of white spot decalcification around brackets.

**Key words:** Bond strength, fluoride

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## الخلاصة

إن عملية زوال كلس الميناء هي من المشاكل المعروفة المصاحبة لعلاج تقويم الاسنان بالأجهزة الثابتة متعددة الأطواق. لقد برزت عدة طرق للتقليل من نسبة حدوث زوال كلس الميناء حول الحاصرات التقويمية. من هذه الطرق الاستعمال الموضعي لمركبات الفلور قبل التخريش، إضافة مركبات الفلور إلى المواد المخرشة، والاستعمال الموضعي لمركبات الفلور بعد التخريش. تعنى الدراسة الراهنة بتقويم تأثير الاستعمال الموضعي لهلام مركبات الفلور قبل وبعد التخريش على قوة إلصاق الحاصرات التقويمية

تشتمل عينة الدراسة على سبعين ضاحكة أولى موزعة على سبعة مجاميع : المجموعة A كانت هي المجموعة الحاكمة . أما المجاميع B1 ، C1 ، D1 فقد حولت لمدة أربع دقائق قبل التخريش للاستعمال الموضعي لهلام فلوريد الصوديوم المتعادل ( ١,١%) وهلام أحادي فلوريد الفوسفات ( ١,٢%) وهلام فلوريد الفوسفات المحمض قليلا ( ١,٢٣%) على التعاقب. بينما المجاميع B2، C2، D2 فقد حولت بعد التخريش لمدة أربع دقائق بنفس الأنواع السابقة لهلام الفلوريد.

تم اختبار قوة القص للحاصرات باستعمال الجهاز الآلي الضاغط العام. وقد تم تسجيل قوة القص بوحدة (Megapascal) . لقد أظهرت نتائج الدراسة الراهنة بان الاستعمال الموضعي لهلام الفلوريد لمدة أربعة دقائق قبل أو بعد التخريش لا يؤثر على قوة القص للحاصرات التقويمية الملتصقة مباشرة على ميناء السن، لكل المجاميع عدا المجموعة D2 حيث أن الاستعمال الموضعي لهلام فلوريد الفوسفات المحمض قليلا قد اثر تأثيرا معنويا بالتقليل من قوة إلصاق الحاصرات في هذه المجموعة.

## INTRODUCTION

Enamel decalcification is a well-recognized problem associated with orthodontic treatment with fixed multibanded appliances. The introduction of directly bonded orthodontic attachments gave some optimism in regard to the reduction of white spot decalcification. The use of bonding rather than banding has reduced the incidence of enamel decalcification, yet the "white spots" are still seen around the bonded attachments.

Several methods have been proposed to minimize the incidence and severity of white spot decalcification around brackets. Among these are the application of topical fluorides before etching, the incorporation of fluorides into the etching agents, and the application of fluorides after etching prior to bonding. Some studies have proposed that the application of fluorides prior

to bonding reduces the bond strength of orthodontic adhesive to enamel surface, while others have recommend the use of topical fluorides before bonding with no danger of compromising the bond strength of the adhesive.

The process of enamel breakdown, resulting in a caries defect, can be described as a series of physicochemical events occurring at or in the immediate vicinity of the enamel / oral fluid interface. Among these is the formation of dental plaque, the influx of fermentable carbohydrate into the plaque, the fermentation of these carbohydrate yielding organic acids, the diffusion of these acids into the enamel, the dissolution of the enamel mineral, and the outward diffusion of the dissolution products to the plaque and the oral fluids<sup>(1)</sup>.

There is no doubt that the prevention of incipient carious lesion is one of the responsibilities of the orthodontist who is concerned about providing high quality of treatment<sup>(2)</sup>.

Zachrisson<sup>(3)</sup> stated that there is much that the orthodontists can do to prevent the demineralization of tooth surfaces.

A method to deliver fluoride to the area beneath and around the bonded attachments, independent of patient compliance, could be very helpful<sup>(4)</sup>. So, by following the evidence that fluoride was responsible for increasing the resistance for enamel demineralization and promoting remineralization, attempts have been made to use different fluorides before, during, and after etching before bonding<sup>(5)</sup>.

## MATERIALS AND METHODS

The sample consisted of seventy extracted human premolars (upper first premolars). These teeth, which were extracted for orthodontic reasons, were collected from the Department of P.O.P. and Department of Oral Surgery in the College of Dentistry, University of Mosul and from some private clinics in Mosul.

The criteria for tooth selection dictated grossly perfect buccal enamel, no caries, no surface irregularities, no restorations, no demineralization, no fracture or cracks caused by extraction forceps. Any tooth with damaged enamel was excluded from the study<sup>(6,7)</sup>. Also teeth with abnormal shapes were excluded from the study.

After extraction, the teeth were debrided of soft tissue remnants<sup>(5)</sup>, and stored initially in (70%) ethyl alcohol<sup>(8)</sup>. Then the teeth were kept in deionized water at room temperature to prevent dehydration<sup>(9)</sup>.

A glass slide was placed on the surveyor table that is previously adjusted in a parallel plane with the base. The tooth was then fixed on the glass slide in an upright position using soft wax at the root apex. The

analyzing rod of the surveyor was used to orient the teeth so that the force could be applied parallel to the tooth surface.

After that, each tooth was embedded in self-curing acrylic<sup>(6)</sup> using a plastic ring, which was placed around the tooth so that only the crown was projecting from the edge of the ring. After complete setting of the acrylic, each tooth was re-checked for the proper orientation with the help of the analyzing rod.

The teeth embedded in the acrylic were re-placed in distilled water at room temperature, to prevent dehydration, until the time of bonding.

The teeth were distributed randomly into (7) groups, (10) teeth each and as follows:

**Group A:** The teeth in this group served as controls, i.e. received no topical fluoride treatment.

**Group B<sub>1</sub>:** The teeth here were treated with topical application of (1.1%) neutral sodium fluoride gel. The gel was applied to the buccal surface of the teeth for (4) minutes prior to etching and subsequent bonding.

**Group B<sub>2</sub>:** The teeth in this group were treated with topical application of (1.1 %) neutral sodium fluoride gel for (4) minutes after acid etching.

**Group C<sub>1</sub>:** In this group the teeth received topical application of (1.2%) sodium monofluorophosphate gel for (4) minutes before applying the acid etching gel.

**Group C<sub>2</sub>:** The teeth here were treated with (1.2%) sodium monofluorophosphate gel which was applied for (4) minutes after acid etching of the enamel surface.

**Group D<sub>1</sub>:** The teeth of this group received a topical application of (1.23%) acidulated phosphate fluoride gel for (4) minutes before acid etching.

**Group D<sub>2</sub>:** Here the teeth were treated with a topical application of (1.23%) acidulated phosphate fluoride gel for (4) minutes after acid etching of enamel surface.

The buccal surface of each tooth was conditioned with (37%) phosphoric acid gel for (60) seconds according to the manufacturer's instructions. Each tooth was then thoroughly rinsed with a water spray for (30) seconds and dried with an oil-free air source for (20) seconds giving the enamel a chalky white appearance<sup>(10,11)</sup>. Transbond adhesive primer was applied to the etched surface with a brush for (20) seconds, oil-free compressed air gently blown, and Transbond adhesive paste applied to the bracket base<sup>(9)</sup>. Care was taken to ensure that the adhesive was completely covering the bracket base. Then, using conventional tweezers, the bracket was gently placed in the middle of the middle third of the buccal surface of the tooth. To standardize the pressure applied to the bracket, the following procedure was followed.

To standardize the pressure, the surveyor was used again. Each sample was held in a special holding device made for this purpose, and placed on the surveyor table, which was already positioned, in a parallel plane with the floor. The bracket was then loaded, for (5) seconds, using a (200) gm load on the top of the surveying arm in which the chisel of the surveyor was inserted. The surveying arm was adjusted so that the chisel was just fitting in the bracket slot. After the (5)-second loading, the sample was unloaded and became ready for polymerization.

All the excessive flash was removed before curing<sup>(12)</sup> using a sharp scaler<sup>(5)</sup>. A Quayle Dental light-curing unit was used for polymerizing the adhesive. The bulb of the unit was replaced by a new one to insure optimum curing, as it was recommended by Newman et al.<sup>(13)</sup> who advised that light bulbs should be changed every six months to avoid a decrease in wave length. The adhesive was cured for (10) seconds from each of the four directions-mesial, distal, occlusal, and cervical to insure complete polymerization<sup>(7)</sup>.

The fluoride gels were applied for (4) minutes, and then the teeth were thoroughly rinsed with a water spray until removing all of the fluoride gels and dried with oil-free compressed air. After that the buccal surface of the teeth were conditioned with (37%) phosphoric acid gel for (60) seconds as it was done in the control group. The acid gel was then rinsed for (30) seconds and dried for (20) seconds. The bonding procedure was proceeded in the same manner as in the control group.

The teeth here were conditioned, rinsed and dried as it was previously done in the control group. The fluoride gel was applied to the etched chalky enamel of the buccal surface for (4) minutes.

After bonding, all the samples were thermocycled (100 cycles from 40 to 56 °C) in an attempt to simulate the oral circumstances<sup>(14)</sup>.

The dwell time was one minute for each bath<sup>(15,16)</sup>. After thermocycling, all the samples were stored at (37)°C in an incubator in distilled water for one week<sup>(17,18,19)</sup>.

After the seven-day incubation period, the samples were tested for their shear bond strengths with a universal compression machine apparatus. The machine was set at a crosshead speed of (0.5) mm/min<sup>(20,21)</sup>.

The force at bond failure was recorded in kilograms, and the shear stress in megapascal (MPa) was calculated by converting the bond force into newtons, and then dividing this by the bracket base bonding area in square meters<sup>(13)</sup>.

The shear bond strength data were initially analyzed using the one-way ANOVA test followed by the Duncun's Multiple Range test to locate the significant differences among the groups.

## RESULTS AND DISCUSSION

The mean values, ranges, and standard deviations of the control group and the groups that were treated with different types of fluoride before etching are given in table (1).

Table (1): Mean shear bond strengths, ranges, and standard deviation of prior-etching fluoride-treated groups

| Group Tested | No. of Sample | Mean* | Range | Min.  | Max.  | S.D   |
|--------------|---------------|-------|-------|-------|-------|-------|
| A (Control)  | 10            | 13.44 | 5.81  | 10.41 | 16.22 | ±1.98 |
| B1           | 10            | 13.36 | 3.31  | 11.66 | 14.97 | ±1.20 |
| C1           | 10            | 13.07 | 5.80  | 10.83 | 16.63 | ±1.96 |
| D1           | 10            | 12.11 | 9.12  | 7.10  | 16.22 | ±2.58 |

\* Mean shear bond strengths are given in Mpa

The application of the one-way ANOVA test, (table 2) revealed that there is no statistical significant difference ( $P < 0.05$ ) between the control group (A) i.e. that did not receive any topical application of fluoride, and groups B1, C1 and D1 that were treated, for 4 minutes prior to etching, with neutral sodium fluoride gel (1.1 %), sodium mono- fluorophosphate gel (1.2%), and acidulated phosphate fluoride gel (1.23%) respectively.

Table (2): One-way ANOVA test for the groups A, B1, C1, and D1

| S.O.V.    | df | SS       | MS     | F Cal.  | F Tab. |
|-----------|----|----------|--------|---------|--------|
| Treatment | 3  | 10.6134  | 3.5378 | 0.8934* | 2.84   |
| Error     | 36 | 142.5539 | 3.9598 |         |        |
| Total     | 39 | 153.1673 |        |         |        |

\* Fcal. < Ftab.; There is no significant difference among the groups A, B1, C1, and D1

The findings of the present study corresponds to the findings of Bryant *et al.*<sup>(8)</sup> who applied the topical fluoride (7) days before bonding and to Hocevar's *et al.*<sup>(22)</sup> who applied the fluoride a day before bonding. These researchers reported no alteration in bond strength. However, in the present study the fluoride gels were applied just before acid etching of enamel surface, yet no significant reduction in shear bond strength was encountered in any group.

The mean values, ranges, and standard deviations of the control group and the groups that were treated with different fluorides, after etching, are listed in table (3).

Table (3): Mean shear bond strengths, ranges, and standard deviation of prior-etching fluoride-treated groups

| Group Tested | No. of Sample | Mean* | Range | Min.  | Max.  | S.D        |
|--------------|---------------|-------|-------|-------|-------|------------|
| A (Control)  | 10            | 13.44 | 5.81  | 10.41 | 16.22 | $\pm 1.98$ |
| B2           | 10            | 11.62 | 5.39  | 8.43  | 13.73 | $\pm 1.97$ |
| C2           | 10            | 13.69 | 7.05  | 10.41 | 17.46 | $\pm 2.18$ |
| D2           | 10            | 10.62 | 7.05  | 7.1   | 14.15 | $\pm 2.21$ |

\* Mean shear bond strengths are given in Mpa

The one-way ANOVA test analysis, table (4) revealed significant differences ( $P < 0.05$ ) among the groups. Therefore, Duncan's Multiple Range test (table 5) was carried out to investigate these differences. The Duncan's test showed that there was no statistical significant difference ( $P < 0.05$ ) between the control group (A) and groups B2 and C2 (neutral sodium fluoride group and sodium monofluorophosphate group respectively), while a significant reduction, as compared to the control group, was found in group D2 (acidulated phosphate fluoride group).

Table (4): One-way ANOVA test for the groups A, B2, C2, and D2

| S.O.V.    | df | SS       | MS      | F Cal.  | F Tab. |
|-----------|----|----------|---------|---------|--------|
| Treatment | 3  | 63.7015  | 21.2338 | 4.8655* | 2.84   |
| Error     | 36 | 157.1089 | 4.3641  |         |        |
| Total     | 39 | 220.8104 |         |         |        |

\*  $F_{cal.} > F_{tab.}$

There is significant difference among the groups A, B2, C2, and D2

Table (5): Duncan's test for the groups A, B2, C2, &amp; D2

| $\bar{T}_i$ | $Y_j$  | LSR** | $Y_{D2} = 10.623$ | $Y_{B2} = 11.68$ | $Y_A = 13.38$ |
|-------------|--------|-------|-------------------|------------------|---------------|
| C2          | 13.698 | 2.05  | 3.066*            | 2.071*           | 0.309         |
| A           | 13.44  | 1.99  | 2.757*            | 1.762            |               |
| B2          | 11.618 | 1.89  | 0.995             |                  |               |
| D2          | 10.62  |       |                   |                  |               |

\* Significant at  $p < 0.05$

\*\* LSR: Least significant range.

The findings of the present study showed that the application of topical fluoride gels after acid etching did not alter the shear bond strength in (2) groups (B2 and C2) as compared to the control group. These findings are in agreement with the findings of Buyukyilmaz *et al.* <sup>(5)</sup>, Bishara *et al.* <sup>(23)</sup>, and Hirce *et al.* <sup>(24)</sup>. Although these researchers have used other types of fluorides, different concentrations and different application time, they all reach the same findings of the present study in that the application of topical fluorides after acid etching do not affect the bond strength significantly.

On the other hand, in the present study, group D<sub>2</sub> showed a significant reduction in shear bond strength as a result of the topical application of acidulated phosphate fluoride gel. This reduction in bond strength can be attributed to higher fluoride uptake by the enamel, which is due to the dilute acid present in this type of fluoride gel. It was reported by Aasenden *et al.* <sup>(25)</sup> and DePaola *et al.* <sup>(26)</sup> that enamel surfaces exposed to an acidified fluoride agent acquired larger amounts of fluoride than those exposed to neutral fluorides. Probably the dilute phosphoric acid incorporated in the acidulated phosphate fluoride gel had a synergistic effect (regarding fluoride uptake) to the (37%) phosphoric acid used for etching.

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