

Comparative Evaluation of Tensile – Bond Strength of An Orthodontic Adhesive with and without Fluoride Application, After Acid Etching -An Invitro Study

J CHANDULAL¹, G YUGANDHAR², I VENKATA RAMANA³, K SRINIVAS⁴, S.SARJEEV SINGH YADAV⁵

ABSTRACT

Background: Fixed appliances hinder the effective control of plaque accumulation and white spot lesions may develop under the ill fitting bands or adjacent to the stainless steel brackets during orthodontic treatment particularly the etching process.

Aims and Objectives: Comparative study of tensile bond strength of an orthodontic adhesive with and without fluoride application after acid etching to know the effect of fluoride on bond strength.

Materials and Methods: This study is carried out on 90 non carious human premolar teeth, and divided in 6 groups with each group of 15 specimens. In those Groups I and IV were control group acid etch treatment, Group II and V is 1.23% APF

gel (acid etch plus APF gel treatment,) and group III and VI is 8% SnF₂ (acid etch plus SnF₂ treatment). Samples of Group I, II and III bond strength were tested after 24 h and groups IV, V and VI after one month on microtensometer machine. The scanning electron microscope (SEM) investigation was carried out for the 2 specimens for the control group after acid etch and 4 specimens after acid etch with fluoride application for fluoride groups.

Results: Control and SnF₂ treated groups was found to be nearly similar to the control group whereas APF treated group showed less focal holes than the other 2 groups.

Conclusion: Fluoride application after acid etching without having an adverse effect on bond strength but we can prevent the white spot lesions and caries.

Keywords: Caries, Enamel demineralization, Orthodontic brackets, Stannous fluoride, White spot lesion

INTRODUCTION

The presence of fixed appliances may hinder effective control of plaque accumulation and white spot lesions may develop under ill fitting bands or adjacent to the brackets during orthodontic treatment. The etched enamel surface has been shown to be a site of increased absorption of outside substances and more susceptible to caries attack.

According to Ogaard and Rolla [1], plaque gets deposited around brackets and the ill fitting bands leading to caries and subsequent enamel demineralization in fixed orthodontic therapy. It has also been observed that the acid etching of enamel before fluoride application increases fluoride uptake.

Various experimental techniques like micro radiography, polarized light microscopy, micro hardness, and electron microscopy have been used to explore the characteristics of carious enamel. Methods like topical application of fluorides prior to etching, after etching and incorporation of fluorides in the etching solutions are said to increase resistance of enamel to caries attack. Studies have shown that caries risk and demineralization can be reduced by good oral hygiene and topical fluoride application.

Hirce et al., [2] stated that application of basic phosphate fluoride or 8% stannous fluoride did not alter the bond strength of the resin adhesive. Bishra and Chann [3] showed that topical applications of acidified sodium fluoride (APF) did not cause significantly lower tensile bond strength.

Buyukyilmaz and Ogaard [4] showed that topical application of titanium tetra fluoride (TiF₄) solutions will not have an adverse effect on the tensile bond strength of orthodontic brackets. Low et al., [5] using a BIS-GMA ultraviolet cured sealant found increased tensile bond strength when 8% stannous fluoride was used.

On the contrary Sheykholeslam et al., [6] reported that use of Stannous fluoride (SnF₂), Titanium tetra fluoride (TiF₄) and Zirconium tetra fluoride (ZrF₄) after acid etching decreased the tensile bond strength of a methyl methacrylate resin.

The present study was done to reexamine the physical presence of reaction products of 1.23% acidified phosphate fluoride (APF) and 8% stannous fluoride on acid etched enamel, which may have any adverse effect on tensile bond strength of bonded orthodontic brackets. The SEM studies were used to assess and substantiate the study results by examining the surface enamel.

MATERIALS AND METHODS

Ninety non carious extracted human premolar teeth collected debrided of soft tissue remnants, cleaned with fluoride free pumice and a rubber cup, preserved in 0.1% thymol solution. The crowns were embedded in aluminum molds filled with resin and catalyst up to their facial surface. The samples were kept in a container filled with distilled water and stored in Yorco incubator at 37°C for 24 h for setting of the resin, later removed from their molds and excess material around the edges was trimmed.

The ninety teeth were divided into six groups with 15 teeth in each Group I and IV are the control groups, Acid etch treatment [Table/Fig-1], Group II and V 1.23% APF gel (Acid etch + APF gel treatment [Table/Fig-1] and Group III and VI 8% stannous fluoride (Acid etch + Stannous fluoride treatment [Table/Fig-2]. Commercially obtained 1.23% APF gel and 8% stannous fluoride is dissolved in distilled water was taken for the study, 30 control teeth were etched with 37% phosphoric acid gel for 60 sec, rinsed for 30 sec with distilled water and dried with compressed air thoroughly.

Group II and V teeth were etched, rinsed and dried in the same way as the control group. Then 1.23% APF gel was applied for 4 min, rinsed, and dried before bracket placement. Group III and VI samples were etched. Then 8% stannous fluoride solution was prepared immediately before use to minimize the effects of hydrolysis and was applied continuously to the teeth with cotton applicator, so that the teeth are kept moist with the solution for four minutes and reapplication of the solution to a particular tooth is done every 15-30 sec, then rinsed and dried before bracket placement. Subsequently, brackets were positioned on six group teeth and allowed to bench cure at room temperature.



[Table/Fig-1]: Control group and APF gel specimens



[Table/Fig-2]: SnF₂ group specimens

Tensile Bond Strength

Samples of I,II,III were removed after 24 h, and IV,V,and VI after one month for bond strength testing. The tensile bond strength of each sample was determined with a “MicrotechTensometer (Microtech 98A/17 Hadapsar, Pune, India) Machine”. The tensile load was applied with a cross head speed of 10mm/minute and the required force to dislodge the bracket was measured in kilograms.

Readings were recorded as the force measured in kg. That was subsequently converted into stress per unit area measured in kg/sq.cm. By dividing the force required to dislodge the bracket base by the nominal area of the bracket base. The nominal area of bracket was determined by using a travelling microscope and was found to be 0.094cm². The brackets used for study is Nibha Contoured Begg Brackets.

Tensile bond strength for each sample was calculated by using the formula:

$$\text{Bond strength} = \frac{\text{Load}}{\text{Nominal area of the bracket}}$$

The values were recorded and statistically evaluated using the ANOVA (Analysis of Variance) test.

Scanning Electron Microscopic Examination: Two extracted sound premolar teeth were selected for surface examination. After cleaning with fluoride-free pumice, and rinsed, then the approximate surfaces were cut down to 2.5x2.5mm enamel blocks. These blocks were cut from each tooth crown. One slab from each surface is applied with 37% phosphoric acid (H₃PO₄), pre-etching with 37% H₃PO₄ followed by 1.23% APF gel, and Pre-etching with 37% H₃PO₄ followed by 8% stannous fluoride. Control group treatment

for etching 60 sec followed by 30 sec rinsing with distilled water and dried. In fluoride groups etched, rinsed, and dried in the same way as the control group. Then fluoride application for four minutes was done, rinsed and dried for 30 sec. The slabs were uniformly coated with gold palladium coating and examined under scanning Hitachi S-520 electron microscope operated at 20KVx2000.

RESULTS

Ninety specimens were divided into 6 equal groups of 15 each. Group I: Control, Group II: Acidulated Phosphate fluoride (APF) Gel, Group III: Stannous Fluoride (SnF₂) Group IV: Control, Group V: Acidulated Phosphate fluoride (APF) Gel, Group VI: Stannous Fluoride (SnF₂) [Table/Fig-3].

S. NO	1 DAY READING (TENSILE BOND STRENGTH) Kg/CM ²			30 DAY READING (TENSILE BOND STRENGTH) Kg/CM ²		
	GROUP I	GROUP II	GROUP III	GROUP IV	GROUP V	GROUP VI
1.	46.70	30.78	32.90	36.09	38.21	32.90
2.	38.21	32.21	36.90	48.83	29.72	32.27
3.	39.27	43.52	31.84	35.03	32.90	31.84
4.	47.77	36.09	42.46	31.84	42.46	43.52
5.	31.84	39.27	54.14	40.33	39.27	37.15
6.	48.83	33.97	38.21	50.95	49.89	30.78
7.	39.27	44.58	36.09	44.58	29.72	32.90
8.	40.33	32.21	36.09	45.64	33.97	38.21
9.	38.21	31.84	40.33	32.90	40.33	30.78
10.	41.40	47.77	37.15	44.58	32.21	36.09
11.	47.77	33.97	38.21	37.15	43.52	40.33
12.	38.21	36.09	44.58	45.64	33.97	31.84
13.	50.95	31.84	35.03	36.09	40.33	38.21
14.	37.15	35.03	31.84	32.90	29.72	44.58
15.	33.97	37.15	43.52	49.89	37.15	41.40
MEAN	41.32	37.22	38.56	40.82	37.29	36.65

[Table/Fig-3]: Showing tensile bond strength and means of all groups in the study

(A) The tensile bond strength of above all groups is compared with one another [Table/Fig-4]. Tensile bond strength of all the specimens tested with “Microtech Tensometer”. The bond strength was measured by using the formula :Bond strength

$$= \frac{\text{Breaking load at which the bond failure occurred}}{\text{(Nominal area of the bracket (0.0942cm}^2\text{))}}$$

The data was statistically evaluated using one-way ANOVA (Analysis of Variance) [Table/Fig-5]

(B) 2 Samples of each group (6 specimens) was submitted to the SEM study for enamel surface examination.

The SEM investigation was carried out for the 2 specimens after acid etching (controlled group) and other 4 specimens after acid etching with fluoride application for fluoride groups.

ANOVA

As per the experimental design the needed one-way ANOVA was carried out for having the level of significance between groups for

GROUP	SAMPLE	MEAN	STANDARD DEVIATION	STANDARD ERROR
I	15	41.32	5.73	1.48
II	15	37.22	4.92	1.27
III	15	38.56	5.83	1.50
IV	15	40.82	6.66	1.72
V	15	37.29	5.74	1.48
VI	15	36.65	4.64	1.19
TOTAL	90	38.64	5.76	0.607

[Table/Fig-4]: Mean and standard deviation values of bond strength by groups

SOURCE	DF	SUM OF SQUARES (MSS)	MEAN SUM OF SQUARES	F.RATIO	F.PROBABILLY
between groups	5	296.81	59.36	1.87	0.1077 N.S.*
within groups	84	2662.70	31.69		
TOTAL	89	2959.51S			

[Table/Fig-5]: One-way Anova
*0.1077 NS= not significant DF: degree of freedom

each of the parameters studied. The ANOVA indicates the level of significance between all the group mean values. It is studied by comparing variance ratio “(F)” of ANOVA calculated with a theoretical value at 5%, 1%, 0.1% level of significance for a given DF. If the calculated ANOVA “F” ratios are more than “F” ratio at 5%, 1%, 0.1% level of significance is noted as either 5%, 1% or 0.1% level.

Variance between the samples is calculated by the formula:

$$\frac{\sum(X-\bar{X})^2}{n-1}$$

Where X= observed formula
X = Mean
n = sample size

Variance between the samples is calculated using the formula

$$\frac{\sigma^2 \sum (nj-1) S_j^2}{nT-k}$$

where nj= sample size
K = No of samples
nT = total observations
Sj= total deviation of sample
“F” test = $\frac{\text{variance between the column}}{\text{Variance between the columns}}$

P>0.05: there is statistically no significant difference of bond strength between the control and fluoride groups.

The results show that there is no statistically significant difference in bond strength between the controlled and the fluoride groups and between the fluoride groups one day and one month readings.

Sem Examinationsurface Effect of Acid Etched Group: Enamel that had been treated with 37% phosphoric acid showed an increased porosity. [Table/Fig-6] shows a generalized roughening of the enamel surface in which numerous opened focal holes are seen.

Surface Effect of Fluoride Treatment: Enamel treated with 37% phosphoric acid pretreated followed by a topical fluoride application of 1.23% APF and 8% SnF₂. The APF treated group [Table/Fig-7] showed less focal holes than the other two groups, where as SnF₂ treated group [Table/Fig-8] was found to be nearly similar to the control group.

DISCUSSION

The present study was done to examine the reaction product of 1.23% of Acidulated Phosphate fluoride (APF) and 8% Stannous

Fluoride (SnF₂) on acid etched enamel which may have any adverse effect on tensile bond strength of bonded orthodontic brackets, and bond measurement done under “Microtech Tensometer Machine”. The SEM studies were used to assess and substantiate the study results by examining the surface enamel.

Ninety human premolar teeth were divided into six groups were used. Group I and IV control (Acid etching + bonding) Group II and V after etching 1.23% APF gel application for 4 min and Group III and VI after acid etching 8% SnF₂ application for 4 min. The tensile bond strength was measured in Group I, II, III after one day (24 h) and Group IV, V, VI was measured after one month (30 d).

The results showed that there is slight decrease of tensile bond strength in APF group compared to that of control group [Table/Fig-3,4]. But, there was no statistically significant difference (p<0.05) in controlled and fluoride groups in one day and one month [Table/Fig-5]. But it could be explained to the presence of phosphoric acid in APF gel. The SEM examination showed that the APF group [Table/Fig-7] has slightly less focal holes than the other two groups.

As per the study the mean bond strength of control group one day reading is 41.32 ±5.73 Kg/cm² and after one month reading is 40.82±6.66 Kgs/cm² [Table/Fig-9]. The APF group is 37.22±4.92 Kgs/cm² and 37.29 ±5.74 kgs/cm² and the SnF₂ group is 38.56 ± 5.83kgs/cm² and 36.65 ± 4.64 kgs/cm². These findings of tensile bond strength reveal no statistically significant (p<0.05) following topical fluoride application and are in accordance with Hirce [2], Wang [7], Bishra SE and Damon PL [8], Thornton [9], Bryant [10] and Buyukyilmaz [11].

The slight decrease of tensile bond strength following APF gel application (group III mean 37.22±4.92 kgs/cm²) compared to that of control group (41.32 ±5.73 kgs/cm²) but are not statistically significant. It could be explained to the presence of phosphoric acid (H₃PO₄) in Acidulated Phosphate Fluoride (APF) gel. It is also supported by SEM study of enamel surface changes seen in [Table/Fig-2]. It was also observed that the APF group has shown slightly less focal holes than the other two groups in the present study. The tensile bond strength for all the groups remains unchanged at the end of 30 days (One month) Wang [7].

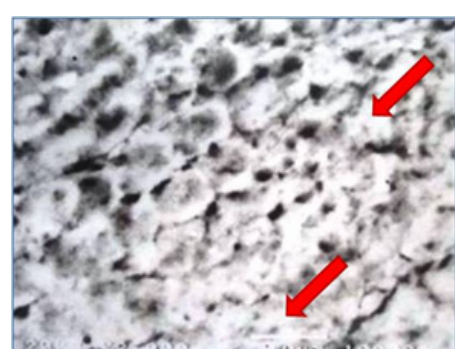
Thornton [9] described the globular structures were seen only on the prism cores of ground enamel surfaces etched with H₃PO₄ containing the higher fluoride concentrations. Similar structures were observed in enamel surfaces subjected to acid pretreatment and topical fluoride application. It was subsequently shown that the globules consisted of Calcium Fluoride (CaF₂). Thereby they did not observe the adverse on the bond strength of the bonding resin to the etched enamel.

Hirce [2] stated use of basic phosphate fluoride (APF) or 8% stannous fluoride does not appear to alter the bond strength of the resin adhesive. Low et al., using a BIS-GMA ultraviolet cured sealant found an increase in tensile bond strength when 8% SnF₂ was used.

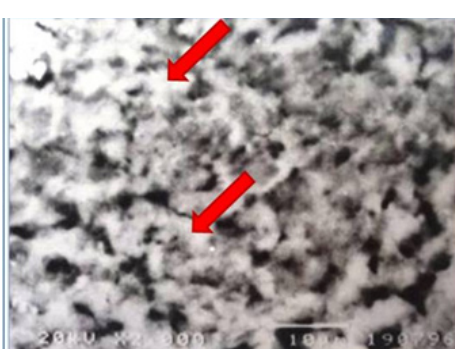
SEM studies by Gwinett [12], Sheykhoslam [6] revealed no overt or gross alterations of the acid etched enamel surface after treatment



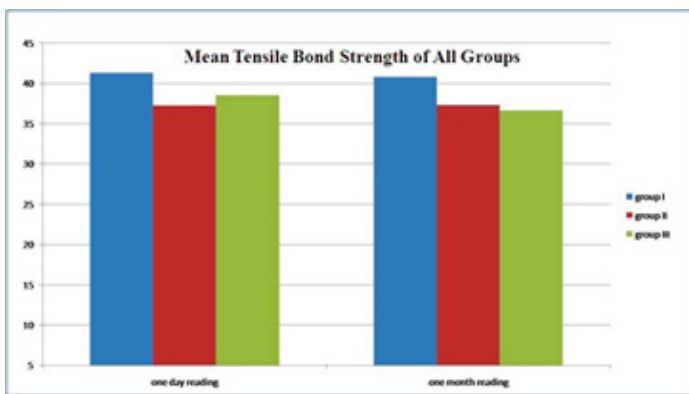
[Table/Fig-6]: Enamel after acid etch



[Table/Fig-7]: Enamel after APF gel application



[Table/Fig-8]: Enamel after SnF₂ application



[Table/Fig-9]: Graph showing mean tensile bond strength of all groups

with stannous fluoride. Kim Mj et al., used a mixture of phosphoric acid and APF gel to lessen the damage of enamel surface during acid etching procedure without any loss of bracket bond strength [13]. Leodido GDA R et al., suggested that the pretreatment of enamel with 1.23 % APF gel and 5 % sodium fluoride varnish before fixing orthodontic brackets reduces shear bond strength values [14]. Al-Kawari HM suggested that the enamel-bracket shear bond strength was found to be significantly increased when fluoride containing casein phosphopeptide amorphous calcium phosphate was applied after acid etching [15].

SUMMARY AND CONCLUSION

This study shows that previous concerns about combining fluoride with bonding procedures have been overemphasized. We suggest that even though fluoride application after acid etching may prevent dental caries, it does not have any adverse effect on bonding strength. We recommend further such studies on a larger sample

to exactly know the effect of fluoride on the bonding strength of orthodontic brackets.

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PARTICULARS OF CONTRIBUTORS:

1. Professor and HOD, Department of Orthodontia, Government Dental College and Hospital, Hyderabad. Telangana, India.
2. Professor and HOD, Department of Orthodontia, Government Dental College, Vijayawada. A.P., India.
3. Associate Professor, Department of Orthodontia, Government Dental College and Hospital, Hyderabad. Telangana, India.
4. Associate Professor, Department of Orthodontia, Government Dental College, Vijayawada. A.P., India.
5. Professor, Department of Conservative Dentistry, Government Dental College and Hospital, Hyderabad. Telangana, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. J Chandulal,
Government Dental College & Hospital, Afzalgunj, Hyderabad-500012. Telangana, India.
E-mail : chandulaljadav@yahoo.com

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