The effect of pretreatment with fluoride on the tensile strength of orthodontic bonding

By Wei Nan. Wang, BDS and Der Horng. Sheen, BDS

White spot decalcification and caries around and under orthodontic bands or bonded attachments are problems of great concern to orthodontists.[1-9] Caries and enamel decalcification can be greatly reduced by maintaining good oral hygiene, applying topical fluorides, and/or using a fluoride-containing dentifrice during orthodontic treatment.[1,10-13] More recent data indicate APF (acid phosphoric fluoride) gels are as good as, if not superior to, other topical fluoride agents.[14]

The mechanism by which fluoride reduces decalcification and caries has also been shown to increase the resistance of enamel to acids, increase the maturation rate of enamel and interfere with the metabolism of microorganisms.[15] Recent evidence shows that fluoride may facilitate the remineralization of white spot lesions.[16] Fluoride can be incorporated in the etching solutions,[1,17] applied topically to the etched enamel surfaces before bonding,[1,18] or applied topically to the enamel surfaces before acid etching.[1]

Several investigators[19-22] have shown that the topical application of fluoride can interfere with the etching effect of phosphoric acid on enamel surfaces, resulting in reduced bond strength of dental resins. In other studies, however,[17,23,24] the topical application of fluoride to enamel surfaces before etching with H_3PO_4 did not negatively affect the etch pattern on the enamel, nor did it affect the bond strength of the bonding resin.

The purpose of the study was to (1) determine tensile bond strength with and without topical fluoride application; (2) detect any change in the enamel following topical APF fluoride application; and (3) evaluate the distribution of debonding interfaces in the two experimental groups.

Abstract

White spot decalcifications and caries occurring adjacent to bonded orthodontic brackets have long been a concern to orthodontists. One procedure suggested to overcome this problem is fluoride treatment prior to bonding. The purpose of this study was to compare the tensile bond strength of orthodontic self-cured resin from Concise on teeth rinsed 4 minutes in 1.23% APF with untreated controls. Measurements were made on an Instron machine. Debonding interfaces were observed with a scanning electron microscope and energy dispersive x-ray spectrometry. Distributions were calculated. The tensile bond strengths of the fluoride-treated teeth and the untreated teeth were not significantly different. The debonding interfaces between resin and bracket base, within the resin itself, and between enamel and resin were similar in the two experimental groups. However, greater enamel detachment was seen within the fluoride pretreatment group. So while fluoride pretreatment does not significantly affect tensile bond strength, it may cause enamel detachment after debonding.

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Key Words

Topical fluoride • Bond strength • Etching enamel • Orthodontic bonding

Table 1

Group	Bond Strength (kg/mm²) Mean	S.D.*
Fluoride pretreatment	0.71	0.13
Without fluoride pretreatment	0.72	0.11

S.D.* = Standard deviation
P>0.05

Materials and methods

Twenty premolars (first or second, maxillary or mandibular) were extracted for orthodontic purposes from patients 9 to 16 years old. The teeth were intact without enamel cracks caused by forceps, were free of caries, and had not been treated with H_2O_2, formalin, alcohol or other substances that might affect bond strength or bond failure interfaces. The extracted teeth were immersed in physiological saline or water for 1 to 3 months, to keep them free from fungal and bacterial contamination, then dried and stored until tested.

The twenty teeth were randomly divided into two equal groups. One group was polished with a fine pumice powder (Moyco Industries, Inc., Philadelphia, Pa.) for 10 seconds, then immersed in APF gel (John O. Butler Company, Ill.) for 4 minutes. The treated teeth were allowed to sit untouched for 30 minutes before the gel was washed off with a 1-minute water spray. The second group of teeth received only the 10-second polishing.

In preparation for bonding, the buccal enamel of each tooth was etched for 15 seconds with Concise acid solution (3M Corporation, St. Paul, Minn.; batch No. 7M). A premolar curved base bracket with mesh pad (Unitek Corporation, Monrovia, Calif.), which had been prefit, was then attached. In order to standardize the bonding area of the resin, the bracket base was outlined on the etched enamel and the surface outside the marked area coated with red enamel polish. The etched enamel and bracket base were coated with a sealant (batch No. A:1922A, B:1922B) and the composite resin (batch No. A1961A, B:1961B) was thoroughly mixed and immediately applied to the bracket base. The bracket was accurately pressed to the demarcated etched buccal enamel with a placement scaler (standardized resin area). The excess resin was removed with a dental probe.

After 24 hours in a 37°C water bath, the bracketed teeth were tested, using an Instron machine (Instron Corporation, Model 1000, Mass.) to determine strength of the bond between the bracket and tooth. The debonding interfaces in each group were further examined using scanning electron microscopy (Canscan Corporation, Serial 4, England) and the mapping of energy dispersive x-ray spectrometry (Phillips Corporation, E.D.A. SW 9100, Holland). Distributive percentages were calculated. Data on bond strengths and debonding interface percentages were recorded and the means as well as standard deviations were determined. Data were analyzed by one-way analysis of variance and means were ranked by a *t*-test calculated at 95% level of confidence.[25] Differences between two means larger than the *t*-interval were noted as statistically significant. Detailed procedures of bond strength tests and debonding interface analyses have been described in previous studies.[26-27]

Results

The bond strength of the fluoride pretreated group was 0.71 kg/mm²; the bond strength of the untreated group was 0.72 kg/mm². The *t*-test at 95% level of confidence denoted that the difference between the two groups was not statistically significant (Table 1). Four types of debonding interfaces were found: interface failure between resin and bracket base; cohesive failure within the resin itself; interface failure between resin and enamel; and surface enamel detachment. The distributive percentages of these debonding interfaces are shown in Table 2.

In the fluoride-treated group, 42% of the failure occurred at the bracket-resin interface, 21% within the resin itself, and 30% at the enamel-resin interface; in 7% of the cases, the enamel itself was detached. In the untreated group, 43% of the failure occurred at the bracket-resin interface, 24% within the resin itself and 33% at the enamel-resin interface; no enamel detachment was found in the untreated group. There were no statistical differences among the debonding interface percentages between the two tested groups. However, enamel detachment was found more often in the pretreated group, and was statistically significant when compared to the other group.

Discussion

In the present study, no statistically significant differences were noted in the tensile bond strength of the treated and untreated groups; this same result has been seen in previous studies.[17,23,24] Since caries and enamel decalcification can be greatly reduced by application of topical fluoride,[1,10-13] pretreatment is recommended for clinical use. In order to keep fluoride on the

Table 2

Group	Metal-resin			Within resin			Resin-enamel			Enamel detached		
	Mean	S.D.	Range	Mean	S.D.*	Range	Mean	S.D.*	Range	Mean	S.D.*	Range
Fluoride pretreatment	42	9.8	25-55	21.0	3.2	5-15	30.0	10.3	25-55	7.0	4.8	0-10
Without fluoride pretreatment	43	11.6	15-50	24.0	4.4	15-30	33.0	11.4	20-60	0	0	0

S.D.* = Standard deviation
$p>0.05$ in each group (except enamel detachment group, $p<0.05$)

tooth surface, repeated topical applications after bracketing are necessary.[10]

Previous studies[19-22] have indicated that topical fluoride application fills in the interprismatic spaces occupied by $Ca_5(PO)_3$ and CaF_2 after etching and thus reduces the bonding capacity of adhesives. Other studies[17,23-24] have shown that tensile bond strength is not significantly different in groups with and without fluoride pretreatment. In these studies, researchers saw globular structures only on the prism cores of ground enamel surfaces etched with H_3PO_4 containing higher fluoride concentrations; they did not observe adverse effects on the bond strength of the bonding resin to the etched enamel. The present study is in agreement with this statement.

The crystalline structure of enamel is made more stable by the acquisition of fluoride which competes with and displaces the hydroxyl groups of the hydroxyapatite molecule to form fluoridated hydroxyapatite.[28] In the present study, APF fluoride gel was applied to teeth in the pretreatment group and was not rinsed off for 30 minutes. Destruction or erosion of the enamel surface may have occurred during this time, accounting for the 7% enamel detachment rate. While the manufacturer suggests that the patient not be permitted to rinse or gargle within 30 minutes of the 4-minute APF application, a similar oral condition was difficult to mimic in this study. In the clinic, the concentration of APF might be diluted by the patient's saliva, the gradual drop and enamel detachment after debonding might be found less often than in this study. The effect of fluoridation on the enamel in this in vitro study was far more pronounced than the effect seen in previous in vivo studies; this topic should be investigated further.

APF gel includes 1.23% NaF and 1% sodium dihydrogen phosphate monohydrate. Previous studies[10,28,30-32] have reported that APF increased the uptake of fluoride by the enamel at rates higher than either stannous fluoride or neutral sodium fluoride. Because of this quality, APF gel was selected as the material for this study.

APF is also easy to apply topically in orthodontic practice. After cleaning and polishing the enamel surfaces with pumice powder for 10 seconds, the patient's teeth are immersed in APF gel in a disposable foam tray for 4 minutes. The patient is not permitted to rinse, gargle or drink for 30 minutes.[29] Following this pretreatment, orthodontic brackets can be placed on teeth according to regular bonding procedures.

The calculating method for the distributive percentage of the debonding interfaces and figures of each debonding interface have been shown in previous studies.[26-27]

Conclusion

With the exception of enamel detachment, no significant differences in bond strength or debonding interfaces were seen in the pretreated and untreated groups. Fluoride pretreatment may offer protection from decalcification or a caries attack, however, it may cause enamel detachment after debonding.

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