

Prevention of demineralization around orthodontic brackets using two different fluoride varnishes

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ABSTRACT

Objective: This in-vitro study was done to evaluate the effects of two different seal materials, Duraflor™ and Enamel Pro® Varnish, on enamel demineralization adjacent to orthodontic fixed appliances.

Methods: Seventy-two extracted solid premolars were allocated to three groups as one control and two study groups after brackets were placed and bonded with Transbond™ XT. The control group received no topical fluoride application after bonding, whereas in the study groups two fluoride varnishes, Enamel Pro® Varnish and Duraflor™ were applied on the teeth adjacent to brackets. All specimens were then immersed separately in demineralization solution for 96 hours at constant temperature. Demineralization of the enamel surface was evaluated quantitatively by cross-sectional microhardness testing: indentations were made at the edge of the bracket base (0 µm) and at 100 and 200 µm distant from it. In all of these positions, 5 indentations were made at 10, 20, 40, 70 and 90 µm of depths from the external surface of the enamel.

Results: The results revealed that, Enamel Pro® Varnish and Duraflor™ group values are higher than the values of control group at every depth. The differences between the depths showed that the microhardness values decreased significantly when the depth increased. In the control group, more demineralization occurred in every indentation compared to the study group.

Conclusion: Duraflor™ and Enamel Pro® Varnish can be considered for use in clinic as an effective method to prevent or reduce demineralization during orthodontic treatment, especially in patients with poor oral hygiene. (Eur J Dent 2013;7:41-47)

Key words: Duraflor™; Enamel Pro® Varnish; demineralization; fluoride varnish; seal material

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INTRODUCTION

During orthodontic treatment, demineralization of the enamel adjacent to brackets is a frequent incidence as a consequence of poor oral hygiene. These demineralizations cause white spot lesions on the tooth surfaces of most orthodontic patients, which does not only result in an unaesthetic appearance but also endangers the success

of the orthodontic treatment.^{1,2} The brackets and other fixed orthodontic appliances are pointed out as one of the main cause for these undesirable lesions since they facilitate the bacteria accumulation by providing retentive areas.³ Previous studies^{2,3} have shown that, in orthodontic patients enamel demineralization could develop only in just one month. At the onset of orthodontic treatment for the patients who lack proper oral hygiene, highly filled sealants can be used during bonding procedure in order to prevent or decrease demineralization.⁴⁻⁶ However, in the absence of good oral hygiene during orthodontic treatment, orthodontists should take additional protective measures to minimize formation of white spot lesions.

Previous studies proved the effectiveness of fluoride regimens like varnish, gel, rinse, and dentifrice,^{3,7,8} but among these methods the use of fluoride rinses that rely on patient compliance might be insufficient and provide only limited benefit in preventing demineralization.^{7,8} On the other hand, it has been shown that varnishes provide high concentration of fluoride to decrease enamel demineralization both in vitro and in clinical trials.⁹⁻¹⁴ They have the advantage of adhering to enamel surface longer than other topical fluoride products, which indicates that their ability to increase fluoride uptake in enamel is better.¹⁵ This will provide prevention against demineralization while allowing the clinician to use proven high bond strength composite resins for bonding. Also, the clinical application is easy and their thorough prophylaxis is not required.¹⁶

Duraflor™ is a fluoride varnish that contains 5% sodium fluoride. Its contact with the enamel allow the formation of calcium fluoride on the tooth surface that prevents demineralization. Besides forming calcium fluoride, it also provides fluoride reservoir on the enamel surface against cariogenic acid attacks over a longer period of time.^{9,17,18}

Enamel Pro® Varnish is another 5% sodium fluoride varnish that additionally contains amorphous calcium phosphate (ACP) formula. Unlike Duraflor™, it delivers ACP to enamel to encourage the formation of hydroxyl-apatite to enhance remineralization and thus prevents the loss of enamel due to demineralization.¹⁹

It is likely that applying ACP containing var-

nishes onto enamel surface around brackets will reduce caries incidence. Sudjalim et al²⁰ found that, using 9000 ppm NaF or caseine phosphopeptide - amorphous calcium phosphate on the bracket base together with Transbond™ XT diminishes enamel demineralization risk.

Recently, some studies pointed out that the composition of caseine phosphopeptide with ACP has more effective anti-cariogenic effect since it stabilizes calcium and phosphate compounds.^{21,22} Caseine phosphopeptide-amorphous calcium phosphate compound increases the calcium and phosphate level in the saliva exceedingly and thus reduces the caries incidence and enhances the effect of topical fluoride.^{23,24}

The aim of this in-vitro study was to compare the effects of 5% NaF containing Duraflor™ and 5% NaF - ACP containing Enamel Pro® Varnish on enamel demineralization around orthodontic brackets.

MATERIALS AND METHODS

Extracted seventy-two non-carious premolars for orthodontic reasons were used in this study. Their buccal surfaces were intact without any cracks or white spots. After the removal of any remaining soft tissue with a scaler, the teeth were stored in 0.1% thymol solution until use. Before experimental use the enamel surfaces were polished with a nonfluoridated pumice and water, rinsed with deionized water and dried with compressed air.

The buccal surfaces of the teeth were conditioned with 38% phosphoric acid (Etch-Rite; Pulpdent Corporation, Watertown, Massachusetts, USA) for 30 seconds followed by thorough washing and drying. Transbond™ XT (3M/Unitek, Monrovia, CA, USA) primer was applied on the etched enamel and polarized for 20 seconds, and brackets were placed on the middle third of the enamel parallel to the long axis with Transbond™ XT adhesive resin. After removing any residual adhesive around brackets with a dental scaler, the specimens were light-cured for 40 seconds with Mectron Starlight pS LED (Mectron s.p.a., Carasco, Italy). The teeth were then allocated to three groups of twenty four as one control and two study groups. The control group received no topical fluoride application after bonding. In the study groups two fluoride varnishes, Enamel Pro®

Varnish (Premier Dental, PA, USA) and Duraflor™ (Medicom, Montreal, Canada), were applied on the teeth adjacent to brackets as recommended by their manufacturers and allowed to dry for 5 minutes.

All specimens were then immersed separately in 2 ml demineralization solution for 96 hours in an incubator at constant temperature of 37°C, with the solution changed every 4 hours. The immersion of the samples in the caries solution for 96 hours represents approximately 3 months of real time.²⁰ The content of the solution used in this study is the same that was used by Gillgrass et al²⁵ The pH of the solution was 4.4 and contained 2.2 mmol/L Ca²⁺, 2.2 mmol/L PO₄⁻, 50 mmol/L acetic acid. After each caries challenge, in order to simulate mechanical wear of the varnish materials the teeth were brushed manually with a soft-bristled toothbrush (Oral B® ortho brush, Procter & Gamble, Cincinnati, Ohio) for 5 seconds. No further application of the varnishes was done after the initial application in the study groups.

In order to assess the mineral loss on the enamel surface, microhardness test was done after the completion of 96 hours. The crowns were separated from the roots and hemi-sectioned vertically in the buccal-palatal direction, through the center of the bracket base with a 15 HC (large) wafering blade on an Isomet low-speed saw (Buehler® Lake Bluff, Illinois, USA). The half-crown sections were embedded in acrylic resin so that the cut surface was exposed according to the methods reported previously (Figure 1).^{25,26} Throughout the study, samples were kept in humid conditions to avoid drying.^{27,28}

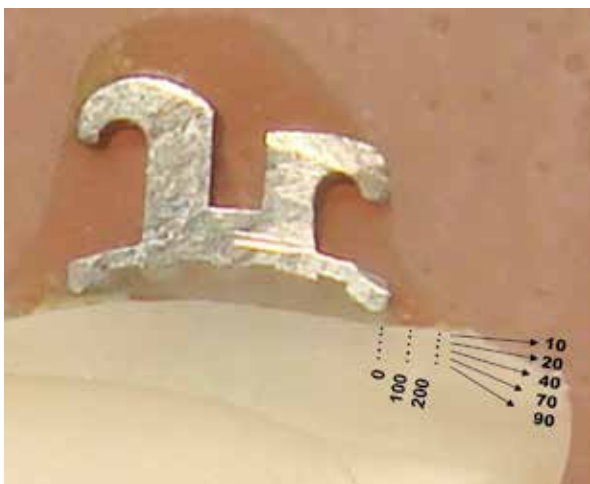


Figure 1. Depths and Region

After serially polishing the samples, demineralization lesions were assessed by microhardness profiles across the cut surface with a micro-hardness tester (Micromet 5114, Buehler®, Lake Bluff, Illinois, USA) fitted with a Vickers diamond. Analyses were done under a 200 g load for 5 seconds as reported by Moura et al²⁶ Fifteen indentations were made in each half crown. Three regions were selected as; edge of the bracket base (0 µm) and at 100 and 200 µm distant to (occlusal side) For per region 5 indentations were made at 10, 20, 40, 70 and 90 µm from the external surface of the enamel (Figure 1).

Statistical calculations were performed with NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) program for Windows. In each thickness group (10-90 µ) repeated measures of Friedman test was used, Kruskal Wallis test was used in the comparison of groups, post Hoc Dunn's multiple comparison test was utilized in the comparison of subgroups, Statistical significance level was established at P<.05.

RESULTS

In our study, the statistical differences of microhardness tests that were applied on the buccolingual surfaces of the teeth are given in Table 1. The results show that statistically significant differences were observed between depths in each group except for the control group.

In the Enamel Pro® Varnish, Duraflor™ and Control groups at the bracket edges (0 µm) and the regions 100 and 200 µm, statistically significant differences were observed at 10, 20, 40, 70 and 90 µm depths. (P=.0001). Microhardness values of the control group were significantly lower than Enamel Pro® Varnish and Duraflor™ groups (P=.0001).

In the Control group at the bracket edges (0 µm) and the regions 100 and 200 µm, there were no statistically significant differences observed at 10, 20, 40, 70 and 90 µm depths. (P=.150). Enamel Pro® Varnish and Duraflor™ group values were higher than the values of Control (Transbond™ XT) group at every depth.

In the Enamel Pro® Varnish group at the bracket edges (0 µm) and the regions 100 and 200 µm, statistically significant differences were observed between 10, 20, 40, 70 and 90 µm depths. (P=.008). Microhardness values of 10µm depth were significantly higher than 20µm, 40µm, 70µm, 90µm depths (P=.045, P=.01), at the 200 µm region 70µm

values were significantly higher than 90µm depth (P=.012). There were no significant differences between other groups (P>.05).

In the Duraflor™ group at the bracket edges (0 µm) and the regions 100 and 200 µm, statistically significant differences were observed between 10, 20, 40, 70 and 90 µm depths. (P=.0001). Microhardness values of 10µm depth were significantly higher than 20µm, 40µm, 70µm, 90µm depths at region 0 µm (P=.041, P=.002), Microhardness values of 20µm depth were significantly higher than 40µm, 70µm, 90µm depths; (P=.002, P=.004) whereas, 40µm values were significantly higher than 70µm and 90µm depths (P=.034, P=.002). At the 90µm depth microhardness values of the bracket edge (0 µm) were found lower than the 100 and 200 µm regions. There were no significant differences among rest of the groups (P>.05).

DISCUSSION

The main causes of enamel demineralization

during orthodontic treatment are the mineral content of the enamel, bacterial plaque accumulation and diet of the patient.²⁵ Demineralization may be prevented or reduced by decreasing the effects of these causes. Although the preventive methods like toothpastes and mouth rinses are effective, they had not been entirely successful since they depend on patient compliance.^{4,29} Therefore, during the last years studies are being made to develop methods that do not need patient compliance. The studies concerning the effects of fluoride varnishes showed that they are much more effective in preventing acid attacks not only due to their high fluoride concentration, but also they have the property of adhering to the enamel surface longer than other topical fluoride products.³⁰ For these fluoride varnishes to be effective, they should be applied by the clinician regularly not only because the high fluoride is enough for preventing decalcification, but also there should be a constant fluoride reservoir in the mouth.^{9,10,31}

Table 1. Statistical differences of microhardness tests.

		Duraflor™	Enamel Pro® Varnish	Control (Transbond™ XT)	
	Depth	Median (IQR)	Median (IQR)	Median (IQR)	p
Region 200 µm	10µ	373.25 (354.8 - 384.88)*‡	361.7 (352.43 - 380.9)* ‡	63.2 (56.3 - 70.6)	0.0001
	20µ	375.15 (360.35 - 389.85)* ‡	337.95 (309.23 - 366.8)* ‡	62.6 (57.13 - 70.98)	0.0001
	40µ	346.1 (338.18 - 362.98)* ‡	314.8 (296.95 - 356.33)* ‡	61.35 (43.08 - 68.1)	0.0001
	70µ	330.4 (325.2 - 348.55)* ‡	328.1 (301.1 - 368.58) *‡	60.5 (42.85 - 64.3)	0.0001
	90µ	312.1 (311.4 - 323.23)* ‡‡	319.45 (280.73 - 349.85) *‡	61.65 (51.1 - 65.1)	0.0001
	p	0.0001	0.008	0.15	
Region 100 µm	10µ	369.65 (355.88 - 383.68)* ‡	352.25 (337.05 - 371.8)* ‡	61.1 (40.03 - 67.73)	0.0001
	20µ	375.35 (360.68 - 385.63)* ‡	330.45 (290.85 - 360.1)* ‡	60.45 (51.43 - 68.68)	0.0001
	40µ	357.8 (338.85 - 367.25)* ‡	312.45 (281.98 - 340.68)* ‡	55.85 (40.75 - 70.7)	0.0001
	70µ	333.1 (327.15 - 350.53)* ‡	340.5 (322.35 - 352.5)* ‡	59.8 (39.55 - 70.72)	0.0001
	90µ	308.6 (301.8 - 316.43)* ‡‡	339.45 (317.7 - 349.6)* ‡	60.8 (37.43 - 70.33)	0.0001
	p	0.0001	0.024	0.708	
Region 0 µm (Bracket edges)	10µ	390.15 (358.45 - 395.3)* ‡	366.9 (343.9 - 384.48)* ‡	62.7 (46 - 75.1)	0.0001
	20µ	365.25 (346.23 - 381.18) *‡	356.45 (301.55 - 385.5)* ‡	58.1 (51.85 - 65.98)	0.0001
	40µ	351.45 (320.15 - 371.48)* ‡	318.95 (306.5 - 362.98)* ‡	58.45 (36.88 - 65.2)	0.0001
	70µ	342.9 (315.08 - 357.6)* ‡	327 (286.05 - 341.98)* ‡	51.6 (37.73 - 66.55)	0.0001
	90µ	276.3 (261.68 - 283.93)* ‡‡	324.05 (303.3 - 351.85)* ‡	49.95 (37.68 - 60.73)	0.0001
	p	0.0001	0.002	0.071	
10µ Depth 200/100/0 R	p	0.173	0.397	0.615	
20µ Depth 200/100/0 R	p	0.308	0.477	0.604	
40µ Depth 200/100/0 R	p	0.72	0.403	0.949	
70µ Depth 200/100/0 R	p	0.729	0.372	0.689	
90µ Depth 200/100/0 R	p	0.0001	0.55	0.245	

Dunn's Multiple Test * Control < D&P P<.0001

Dunn's Multiple Test ‡ D group 10µ> 20,40,70,90µ 20µ> 20,40,70µ P<.05 group 10µ> 20,40,70,90 P<.05

Dunn's Multiple Test † K0 < K100-K200 P<.0001

Duraflor™ forms calcium fluoride on enamel surface and this supplies a fluoride reserve against acid attacks in the mouth. Thus, it is effective in inhibiting demineralization on enamel surface. According to our results, Duraflor™ group showed less demineralization than control (Transbond™ XT) group in all of the depths.

Gorton and Featherstone,² Sudjalim et al²⁰ Banks and Richmond³² and Schmit et al³³ found Transbond™ XT is ineffective in preventing demineralization similar to our findings.

Likewise our study Todd et al⁹ applied Duraflor™ onto the enamel around orthodontic brackets which were bonded to extracted human teeth and found similar results. It was concluded that the teeth applied with Duraflor™ exhibited 50% less demineralization. Enamel Pro® Varnish, which is another 5% NaF containing varnish, deposits not only fluoride but also ACP (amorphous calcium phosphate) onto the enamel surface. Unlike Duraflor™, it inhibits demineralization by making “amorphous calcium phosphate crystals” and forming “apatite” on enamel surface.

In a study, Schumacher et al³⁴ exhibited that a biologically active material containing ACP might inhibit demineralization by the way of releasing cavity fighting components including calcium and phosphate similar to our findings.

Skrtic et al¹⁹ reported that 71% of mineral content of demineralized teeth might be recovered by the use of ACP-filled composite resins, which is similar to our finding for Enamel Pro® Varnish group showed higher microhardness values between all the regions and at all depths when compared to the control group.

Skrtic et al^{19,35} and Antonucci et al^{36,37} found out that the ACP-filled polymers were very suitable to release saturated levels of calcium and phosphate ions for the formation of hydroxyapatite crystals, which is very effective both in inhibiting demineralization and enhancing remineralization.

The higher affinity of ACP to fluoride makes it capable of releasing nearly four times as much fluoride to oral environment when compared to the conventional transparent varnishes. Because ACP stabilizes the calcium and phosphate ions in the saliva, it inhibits demineralization of enamel and even dentin.^{21,22}

In our study, no statistically significant difference was found between Enamel Pro® Varnish

and Duraflor™ groups ($P > .05$), whereas, these two study groups showed significantly higher microhardness levels than Control (Transbond™ XT) at all regions and depths. Enamel Pro® Varnish and Duraflor™ had similar effects in inhibiting and preventing demineralization of enamel.

Similar to our findings, Dunn³⁸ concluded that ACP containing materials are very effective in preventing demineralization due to inadequate oral hygiene and microleakage and also in accelerating the remineralization of the decalcified teeth.

Also, Uysal et al³⁹ found that Aegis-Ortho material that contains ACP is effective in preventing demineralization resulting from inadequate oral hygiene and microleakage. However, its bonding strength was found less than Transbond™ XT.

The findings of the present study suggest that both ACP-containing fluoride varnishes and traditional fluoride varnishes are effective in preventing demineralization of the teeth due to poor oral hygiene. Future in vivo studies, examining the efficacy of these varnishes in preventing enamel demineralization, appear warranted.

CONCLUSIONS

With the limitation of this in-vitro study, It is concluded that fluoride-containing varnishes are very effective in both preventing and inhibiting demineralization since they have high fluoride concentration. Duraflor™ (5% NaF) and Enamel Pro® Varnish (5% NaF + ACP) had similar effects for inhibiting and preventing demineralization of enamel.

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