ORIGINAL RESEARCH

Effectiveness of Various Dental Varnishes in Prevention of Enamel Demineralization around Orthodontic Brackets: An *In Vitro* Study

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Abstract

Aim: The present study aimed to assess the efficacy of different dental varnishes in prevention of demineralization of enamel along the orthodontic brackets.

Materials and methods: A total of 60 premolars that do not have caries and were extracted for orthodontic purposes were used in this study. Transbond™ Plus was used to bond premolar brackets onto the treated surface of enamel. The teeth were then divided into three groups. Group I: Profluorid varnish, group II: CPP-ACP varnish, and group III: Duraflor™ varnish. A Vickers diamond indenter was used to assess the microhardness of the surface of enamel at baseline, fourth day, and seventh day.

Results: A slightly meaner surface microhardness (SMH; 334.20 ± 2.10) was seen in group III when compared with group I (332.16 ± 3.02) and group II (330.40 ± 2.02). The mean SMH was 342.02 ± 0.82 in group I on the fourth day which was slightly higher than that of the baseline values, followed by group III (339.48 ± 0.34) and group II (336.64 ± 1.14). No statistically significant differences were noted between the groups. A higher mean microhardness of 349.84 ± 0.66 was seen in group I on the seventh day, followed by group III (342.26 ± 1.08) and group II (338.18 ± 1.08). A statistically highly significant difference was seen between the groups.

Conclusion: The present study concluded Profluorid varnish to have maximum potential to reduce demineralization of enamel followed by Duraflor and casein phosphopeptide–amorphous calcium phosphate (CPP-ACP) group.

Clinical significance: A most common clinical challenge encountered in orthodontic clinical practice is enamel demineralization or white spot lesion (WSL) development throughout the fixed appliance treatment. Thus, the information about several available varnishes is important to prevent demineralization in regular dental practice.

Keywords: Brackets, Demineralization, Orthodontic treatment, Varnish.

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Introduction

Loss of mineralization of enamel is sequential to orthodontic treatment and is exacerbated by bad oral hygiene. Initial stages of enamel caries result in loss of mineral along the subsurface with an undamaged enamel on the upper surface. The demineralized enamel reflects light differently than healthy adjacent enamel resulting in a chalky white image. White spot lesions (WSLs) look as tiny lines along the orthodontic brackets in few patients, while they may appear as big unmineralized zones either without cavitation or with cavitation. Identification of WSLs post-orthodontic appliance removal is completely unpromising.[1]

Even though this undesirable complication has been identified by orthodontists and many have taken effective measures to reduce, the formation of white spot and development of caries in patients who do not follow aggressive caries preventive measures during orthodontic treatment still remains a problem. As these conditions are irreversible, not healthy and esthetically unpleasing, it is mostly unpromising to that branch of dentistry which primarily aims to enhance dental and facial esthetics.[2]

Several specialized preventive measures are suggested for patients undergoing fixed orthodontic treatment as the prevalence of WSLs in patients receiving orthodontic treatment is approximately 68.4%. It is the responsibility of an orthodontist to reduce enamel demineralization by providing timely education and drive the patient to achieve good oral cleanliness. Local/

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topical fluoride application (fluoride-containing varnishes, gels and mouthwashes, and high-fluoride toothpaste) has been found to be efficacious in preventing caries and WSL management of during and after orthodontic treatment.[3]

Different categories of varnishes of various concentrations and compositions were prepared. The most common fluoride varnish is sodium fluoride (NaF) varnish. Its performance depends on calcium fluoride (CaF_2) formation. Additionally, it provides a reservoir of fluoride on the surface of enamel which helps fight acid attacks by caries during an extended time period.[4] Yet another novel remineralization method includes use of products obtained by milk casein such as casein phosphopeptide–amorphous calcium phosphate with fluoride (CPP-ACFP) and casein phosphopeptide-stabilized amorphous calcium phosphate complexes (CPP-ACP). The important advantages of these materials are mainly due to their characteristic feature to confine on tooth surface and integrate with plaque present supragingivally to deliver bioavailable calcium (Ca) and phosphate (P) ions where they are required most.[5] Thus, this study aimed to evaluate the efficacy of different dental varnishes in avoidance of enamel demineralization along the orthodontic brackets.

Materials and Methods

The present *in vitro* study was conducted in the Department of Orthodontics, RajaRajeswari Dental College and Hospital, Bengaluru. Totally, 60 premolars (Fig. 1) that are non-carious and were extracted for orthodontic purpose were used in this study. These teeth had no white spots or cracks on their buccal surfaces. The remnant soft tissue on teeth was removed using a scaler. After this, the teeth were submerged in thymol solution (0.1%) till use. Just before investigational usage, hydrated nonfluoridated pumice was used to polish the enamel surfaces. The teeth were later washed with deionized water and dried up with compressed air.

Bonding Procedure

The phosphoric acid (37%) was used to treat the surface of enamel for 30 seconds. The tooth was cleansed using water for next 30 seconds and dried. A disposable brush was used to apply a thin even coat of resin sealant on the area that was etched and mildly air-dried. A spatula was used to apply the paste gently onto the bracket base following which the bracket was immediately positioned onto the surface of tooth. As per manufacturer's instructions, Transbond™ Plus was used to bond premolar brackets onto the treated surface of enamel. The brackets were placed parallel to the long axis of the tooth on the buccal surface and were positioned along the mid one-third occlusogingivally and at the mesiodistal height of contour. The brackets were seated completely by pressing on the enamel surface. A clinical probe was used to carefully remove the additional adhesive present along the bracket prior to curing. A curing unit of visible light was used to cure the bonding agent for 20 seconds.

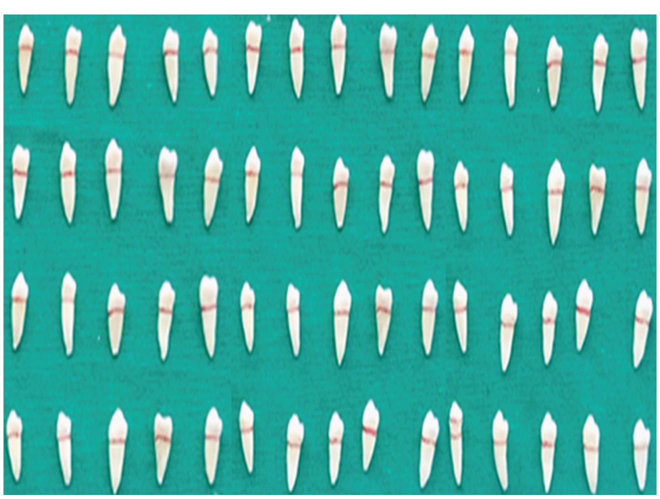

Fig. 1: Samples used in this study

The teeth were then divided into three groups. The manufacturer's instructions were followed for all materials:

Group I: Profluorid® Varnish (VOCO GmbH, Cuxhaven, Germany)

Profluorid varnish was applied on the labial surfaces around the brackets, and it was allowed to dry for 5 minutes.

Group II: CPP-ACP (GC Tooth Mousse; GC Corp., Tokyo, Japan)

CPP-ACP was coated and left undisturbed for 3 minutes. The excess material was removed using cotton roll and let to dry for another 2 minutes.

Group III: Duraflor (Medicom, Montreal, Canada)

Duraflor varnish was smeared on the teeth next to brackets as suggested by its manufacturers and let to dry for 5 minutes.

All teeth were then submerged individually in demineralization solution of 2 mL quantity for 96 hours at 37°C in an incubator, with the solution replaced after 4 hours. The composition of the solution tried in this study is same as that used by Gillgrass et al.[6] The solution composed of 2.2 mmol/L each of PO_4^- and Ca^{2+} and 50 mmol/L acetic acid at a pH of 4.4. In order to mimic the loss of varnish materials on the teeth due to mechanical wear, a soft bristled toothbrush (Oral BR ortho brush; Procter and Gamble, Cincinnati, Ohio, USA) was used to brush the teeth manually once for 5 seconds. The varnishes were not re-applied post initial application. All teeth were later rinsed with water and kept in commercially available artificial saliva (this creates an oral environment in the laboratory) for almost 15 hours till the analysis of surface microhardness (SMH) test was done. All procedure was carried out by a single calibrated investigator.

SMH Testing

The microhardness test was performed on the teeth which were stored in artificial saliva and taken after 96 hours to evaluate the extent of mineral loss on the surface of enamel. A Vickers diamond indenter (Fig. 2) burdened with 25 mg was used for about 10 seconds to perform the microhardness test. The average SMH for every sample was estimated to be five indents (Fig. 3) at baseline, fourth day, and seventh day.

Statistical Analysis

SPSS software of version 17.0 was used to calculate the mean and standard deviation (SD). One-way analysis of variance was used to measure comparisons between and within different varnishes. The calculations with p value less than 0.05 were taken as statistically significant.

Results

Table 1 displays the mean microhardness values of all the three groups prior to the application of varnish. A slightly meaner SMH (334.20 $\pm$ 2.10) was shown by group III when compared with group I (332.16 $\pm$ 3.02) and group II (330.40 $\pm$ 2.02). No statistically significant difference was seen between the groups by an analysis of covariance.

Table 2 shows the comparison of mean microhardness with different dental varnishes on the fourth day. The mean SMH of group I (342.02 ± 0.82) was found to be slightly higher than that of the baseline values, followed by group III (339.48 ± 0.34) and group II (336.64 ± 1.14). No statistically significant differences were noted between the groups.

Table 3 shows the seventh day comparison of mean microhardness with different varnishes. A higher mean microhardness value of 349.84 ± 0.66 was shown by group I, followed by group III (342.26 ± 1.08) and group II (338.18 ± 1.08). Statistically, a highly significant difference was observed between the groups.

Table 4 displays multiple comparisons of the different varnishes. A statistically significant difference was seen between group I and group II and between group I and group III.

The inference of the present study indicates that the Profluorid varnish group showed the highest potential to decrease enamel demineralization followed by Duraflor and CPP-ACP group, respectively.

Fig. 2: Surface microhardness measured using a Vickers diamond intender

Discussion

The toughest challenge faced by orthodontists is prevention of WSL formation or demineralization during orthodontic treatment. Many preventive procedures have been used in the literature for this purpose. *In vitro* use of laser irradiation has been extensively studied and has been proven to be effective in enhancing resistance of enamel to demineralization, signifying that it might be beneficial during orthodontic treatment. The irradiated portion of the tooth had a smooth surface with a small number of cracks although the clinical application of lasers during orthodontic treatment for a preventive purpose is still limited.[7]

Throughout the orthodontic treatment, the presence of bonded brackets helps accumulation of dental plaque and makes

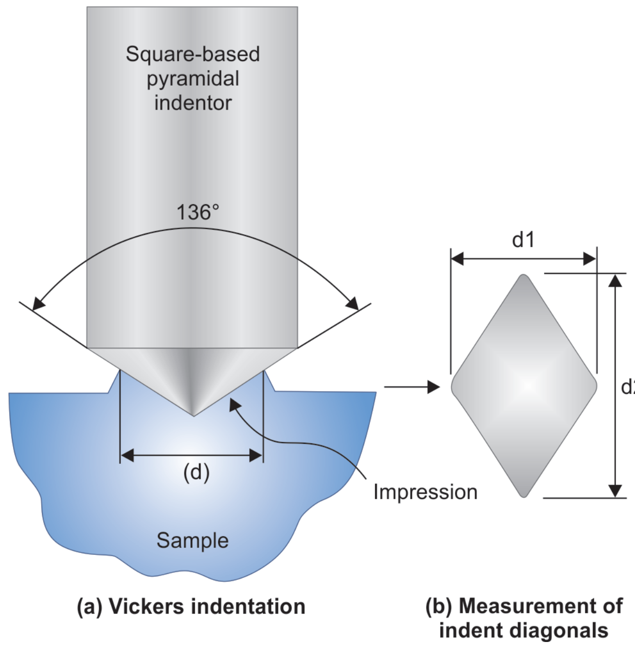

Fig. 3: Schematic diagram for surface microhardness testing

Table 1: Mean microhardness values of all the three groups before the application of varnish

Varnishes	*Mean ± SD*	*Standard error*	*F*	*p value*
Group I: Profluorid varnish	332.16 ± 3.02	0.1226	26.132	0.910
Group II: CPP-ACP	330.40 ± 2.02	0.0174		
Group III: Duraflor	334.20 ± 2.10	0.0356		

Table 2: Comparison of mean microhardness with different dental varnishes on the fourth day

Varnishes	*Mean ± SD*	*Standard error*	*F*	*p value*
Group I: Profluorid varnish	342.02 ± 0.82	0.0242	28.182	0.06
Group II: CPP-ACP	336.64 ± 1.14	0.0813		
Group III: Duraflor	339.48 ± 0.34	0.1018		

Table 3: Comparison of mean microhardness with different varnishes on 7th day

Varnishes	*Mean ± SD*	*Standard error*	*F*	*p value*
Group I: Profluorid varnish	349.84 ± 0.66	0.2164	29.220	0.001
Group II: CPP-ACP	338.18 ± 1.08	0.0349		
Group III: Duraflor	342.26 ± 1.08	0.5201		

Table 4: Multiple comparisons of different varnishes using Tukey's *post hoc* test

Groups	*Compared with*	*Mean difference*	*Significance*
Group I	Group II	11.66	0.001
	Group III	7.58	0.04
Group II	Group I	−11.66	0.001
	Group III	−4.08	0.07
Group III	Group I	−7.58	0.04
	Group II	4.08	0.07

it difficult to maintain oral hygiene. The use of fluoride varnishes could be a preventive method. The application of fluoride varnish around orthodontic appliances has shown to reduce the occurrence of WSLs. Around 50% reduction in occurrence of WSLs has been demonstrated with the use of fluoride varnish containing 5% sodium fluoride in a resin base.[8] Hence, intermittent application of fluoride may offer a clinically operative solution, while it was seen that WSLs cannot be completely prevented by such materials. Furthermore, fluoride varnish application on lesions that are already present prevents their advancement and might help remineralization.[6]

Our study found Profluorid varnish to be more effective than the other investigated materials in preventing the loss of minerals from enamel along the brackets. These findings are in agreement with Nalbantgil et al.,[9] Vivaldi-Rodriques et al.,[10] Ulkur et al.,[11] and Farhadian et al.[12] This is because Profluorid varnish produces CaF_2 deposits and results in F deposition in microchannels and porosities in enamel surface, thus preventing enamel demineralization.

Duraflor provides a reservoir of fluoride on the enamel surface that prevents acid attacks in the mouth by forming calcium fluoride. Therefore, it is beneficial in preventing enamel surface demineralization. We found less demineralization in Duraflor group than CPP-ACP group. This finding is in accordance with those observed by Gorton and Featherstone[13] and Sudjalim et al.[14]

Another study conducted by Todd et al.[15] also applied Duraflor on the enamel surface along orthodontic brackets which were bonded to extracted human teeth and achieved comparable results. A 50% less demineralization was observed in teeth onto which Duraflor was applied. Enamel Pro varnish containing 5% NaF deposits both fluoride and amorphous calcium phosphate (ACP) onto the enamel surface. Enamel Pro varnish makes “amorphous calcium phosphate crystals” and forms “apatite” on enamel surface and this is dissimilar to Duraflor. This provides a reservoir of fluoride on enamel surface that prevents acid attacks in the mouth by forming calcium fluoride.

In the present study, simulations of series of enamel demineralization and remineralization that ensue below dental plaque in oral cavity were developed. To mimic demineralization process and remineralization by saliva in the oral cavity, a laboratory pH altering model was developed; this was similar to the study conducted by Featherstone et al.[16] shows an exponential quantitative relationship between fluoride concentration and inhibition of apatite demineralization or enhancement of remineralization.

In the present study, *in vitro* enamel SMH was evaluated post-application of three different varnishes. The Vickers hardness measuring test was used to assess microhardness after oral condition simulation in the laboratory. The pH cycling method creates an oral environment in the laboratory by generating acidic challenges. Nevertheless, 100% imitation of oral conditions cannot be projected in the laboratory because of the important and vital factors interrelated with the remineralization process such as flow rate and speed of saliva, its composition, and buffering capacity.[17]

The CPP-ACP varnish group demonstrated smallest reduction in demineralization. This finding is in accordance with those of Behnan et al.,[18] Shetty et al.[19] The reduced effect of prevention of demineralization of enamel by CPP-ACP varnish could be due to longer application time that may be needed to provide the chosen effect (release of ACP from CPP and deposition of Ca and P onto the enamel surface). This is different from the results obtained by Lata et al.[20] who did not find any beneficial effect of fluoride addition to CPP-ACP on enamel remineralization clinically.

The limitations of this study were that first premolars were the only included teeth with demineralization of other teeth not being examined. The gender- and age-related variations for demineralization were not considered in the design of this study. Being an *in vitro* study may also hinder the results due to simulation of the environment varies. The above-stated parameters must be considered in future studies. Other commercially available fluoride varnishes also can be compared with these varnishes.

Conclusion

The present study concluded Profluorid varnish to have maximum potential to reduce demineralization of enamel followed by Duraflor and CPP-ACP group. Enamel demineralization or WSL development during orthodontic treatment with fixed appliances is a common clinical problem in modern orthodontic practice. Therefore, in routine clinical practice, the knowledge about different varnishes is of importance to prevent demineralization.

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