Comparison of Effect of Fluoride Varnish, Fluoride-releasing Composite, and Casein Phosphopeptide-amorphous Calcium Phosphate Fluoride on Demineralization around Brackets: An in vivo Study

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ABSTRACT

Introduction: White spot lesions are a major problem in orthodontic patients as they compromise esthetics. They are the result of decalcification of enamel that occurs around brackets. This in vivo study was conducted to evaluate the effect of three different forms of topical fluoride on enamel demineralization adjacent to bonded brackets.

Materials and methods: A total of 24 patients who needed extraction of at least two premolars for orthodontic reasons were selected. In each patient, one premolar was the test tooth and the other was the control. Brackets were bonded but only the test teeth received topical fluoride, that is, Transbond PLUS Color Change Adhesive, bifluoride12, GC Tooth Mousse Plus. The premolars were extracted after 80 to 90 days, and buccolingual sections 50 to 70 μm in thickness were evaluated with polarized light microscopy. The mean depth of demineralization in each lesion was measured using the software Image Pro Plus.

Results: The difference between the values of the depth of demineralization in the experimental and control samples of all groups was found to be statistically significant (p < 0.05). There was a 43.3% reduction in the lesion depth in the transbond plus group. There was a 67.4% reduction in the lesion depth in the GC tooth mousse group. There was a 70% reduction in the lesion depth in the bifluoride varnish group.

Conclusion: Enamel demineralization around brackets is significantly reduced by all the three materials used in this study. The highest amount of lesion depth reduction was seen in the Bifluoride varnish group. Transbond plus, was the least effective among the three materials used.

Keywords: White spot lesions, Fluoride-releasing adhesive, Fluoride varnish, Casein phosphopeptide-amorphous calcium phosphate, Orthodontic brackets, Enamel demineralization.


INTRODUCTION

Decalcification of enamel surface adjacent to fixed orthodontic appliances is an important and prevalent iatrogenic effect of orthodontic therapy. The bonding of orthodontic appliances to teeth increases the number of plaque retention sites, resulting in compromised oral hygiene. The low pH of plaque adjacent to orthodontic brackets hinders the remineralization process, and decalcification of enamel can occur. As enamel translucency is directly related to the degree of mineralization, initial enamel demineralization usually manifests itself clinically as a ‘white spot lesion’ (WSL).1,2

The prevention, diagnosis, and treatment of WSLs is crucial to prevent tooth decay as well as minimize tooth discoloration that could compromise the esthetics of the smile. Many methods like improving oral hygiene, modifying diet (low carbohydrate), and treatment with topical fluorides can decrease or prevent WSLs. Most of these methods, however, rely on patient compliance, which is unreliable, and is seen only in 13% of orthodontic patients. Attempts have been made to use compliance-free methods.3

It is widely accepted that fluoride exerts its anticariogenic properties by the formation of fluoroapatite in outer enamel surfaces. Topical fluoride applications and several other forms of fluoride are being evaluated for their efficiency in preventing WSL.4 This study focuses on comparison of three different fluoride-releasing products in preventing demineralization around brackets.

AIMS AND OBJECTIVES

The aim of this study is to compare the effect of fluoride-releasing adhesive and topical fluoride applications in preventing enamel demineralization using fluoride in a
form that would at best overcome the disadvantages of the other methods.

OBJECTIVES

1. To evaluate and compare the effects of fluoride releasing composites, casein phosphopeptide-amorphous calcium phosphate fluoride (CPP-ACP), and fluoride varnish on enamel demineralization around brackets.
2. To compare the amount of enamel demineralization around brackets in teeth of the same individual, with and without fluoride application.

MATERIALS AND METHODS

The present in vivo study was planned to evaluate the depth of enamel demineralization around the orthodontic bracket surface by using three different materials.

The three experimental materials that were used in the study are as follows:
1. Transbond PLUS Color Change Adhesive (3M UNITEK, Monrovia, California).
2. Bifluoride12 varnish (VOCO, Cuxhaven, Germany).

METHODOLOGY

Patients who had to undergo fixed orthodontic therapy reporting to the Department of Orthodontics and Dentofacial Orthopedics, Vishnu Dental College, Bhimavaram and require therapeutic extractions of at least two premolars as a part of the treatment were chosen. Ethical committee clearance was obtained for the use of natural teeth of humans in the study.

The inclusion criteria are as follows:
1. Anatomically and morphologically well-defined teeth.
2. Noncarious maxillary upper first premolar teeth with intact buccal enamel, extracted for orthodontic purpose.

The exclusion criteria are as follows:
1. Teeth with heavy restorations.
2. Variations in crown with enamel structural defects.
3. Fractured crowns.
4. Fluorosed teeth.

This clinical trial has been conducted using split mouth technique. Hence, the experimental and control teeth, both were from the same patient. The experimental and control teeth were alternately selected on the right and left side in different patients. The subjects were allotted into three different groups.

In each patient, one premolar was the experimental tooth (bonded with fluoride-releasing composite or topical application of bifluoride varnish/GC Tooth Mousse), and the other was the control tooth (no topical fluoride application). The experimental and control teeth, a total of 72, in all the subjects together were alternately selected on the left and right. After cleaning the teeth with nonfluoride pumice, stainless steel PAE/Begg brackets were bonded to the center of the teeth with Transbond PLUS Color Change Adhesive (3M UNITEK, Monrovia, California) in the first group and with Transbond XT Adhesive (3M UNITEK, Monrovia, California) in the second and third group.

The experimental teeth in the first group received topical fluoride in the form of fluoride-releasing adhesive. The patients of the second group were advised to apply GC. Tooth Mousse on the experimental teeth and bifluoride varnish was applied around brackets of the experimental teeth in the third group.

The experimental and control teeth were extracted after 80 to 90 days. The extracted teeth were cleaned with distilled water and stored in 0.1% thymol solution. The extracted teeth were sectioned approximately 1 mm above the cementoenamel junction such that only the crown portion remained. The crown portion was then embedded half-way into self-cure acrylic resin to expose half of the buccal and lingual surfaces in the mesiodistal direction.

The acrylic blocks were then placed on a hard tissue microtome (Leica SP1600), tooth was sectioned at the base of the exposed portion leaving half of the tooth embedded in the acrylic block (Fig. 1). A thin section was then made through the acrylic block thereby resulting in a longitudinal section of the crown of about 100 to 150 µm thickness. The sections were then further reduced to make finer ground sections of 40 to 60 µm thickness with hand grinding on a silicon carbide stone.

The sections were mounted on slides and evaluated for the amount of enamel demineralization using a research microscope (Olympus BX 51) with polarized light attachments. The microscopic pictures were taken with a DP71 camera and stored in a computer and the depth of demineralization was measured in areas were polarization was seen using the software Image Pro Plus Version 6.2 (Cybernetics Inc.) (Fig. 2). The depth of enamel demineralization among the three groups and also between the experimental and control teeth of each group was noted in microns. The data were then subjected to statistical analysis.

RESULTS

The results obtained from the three groups of samples were tabulated. Descriptive statistics including mean, standard deviation, and minimum and maximum values were calculated for the depth of demineralization in enamel of the three groups were studied and then subjected to following statistical
evaluation to determine the statistical significance of the data between the experimental and control samples of each group and also between the groups.

- Mean and standard deviation
- Student’s independent t-test
- One-way analysis of variance (ANOVA)
- Multiple comparison test (post hoc test) with homogenous subsets by Duncan.

The values of the depth of demineralization in enamel of the experimental and control samples of all the three groups are tabulated in Table 1.

It is evident from Table 1 that the minimum depth of demineralization that was noted was 0.00 µm, that is, no demineralization at all in one tooth that belonged to the GC Tooth Mousse experimental group. The maximum depth of demineralization noted in an experimental group was 94.31 µm which was a sample that belonged to the Transbond XT Plus group. The minimum depth of demineralization noted in a control group was 45.50 µm which was noted in a sample that belonged to the GC Tooth mousse group. The maximum depth of enamel demineralization that was noted in a control group was 124.84 µm which was in a sample that belonged to the bifluoride varnish group.

The values of the demineralization depths in enamel were analyzed to calculate their mean, standard deviation to determine if there was any statistically significant difference between the experimental and control samples of each group and presented in Table 2.

The difference between the values of the depth of demineralization in the experimental and control samples of all the groups was found to be statistically significant (p < 0.05). There was found to be a 43.3% reduction in the lesion depth in the experimental samples as compared with the control samples of Group I (see Table 2). There was found to be a 70.06% reduction in the lesion depth in the experimental samples as compared with the control samples of Group III (see Table 2).

The results obtained after the statistical evaluation and comparison of the depth of demineralization in enamel of all the three experimental groups are shown in Graph 1.

ANOVA was applied to the three experimental groups for comparison within the groups. It is evident from Graph 1 that there was a statistically significant difference in the mean depth of enamel demineralization among the three experimental groups (p < 0.05). Therefore, a multiple comparison test (post hoc test) was used for pairwise significant difference between the three groups.

It is evident from Table 3 which shows that by using the homogenous subsets by Duncan, statistically significant differences were not found between the Groups II and III, that is, the GC tooth mousse group and the bifluoride varnish group, whereas Transbond XT Plus Group values for the depth of demineralization in enamel were statistically different from the other two groups.

The results obtained after the statistical evaluation and comparison of the depth of demineralization in enamel of all the three control groups in each of the three groups in the present study are presented Graph 2.

It is evident from Graph 2 that there are no statistically significant differences between the control samples of the three groups (p > 0.05).

**DISCUSSION**

Clinical experience shows that the use of fixed appliances in orthodontic treatment increases the risk of enamel demineralization, especially in conjunction with compromised oral hygiene.5
Table 1: Scores of depth of demineralization (in microns) in the control and experimental samples of all the three groups

<table>
<thead>
<tr>
<th>S. no.</th>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transbond Plus</td>
<td>GC Tooth Mousse Plus</td>
<td>Bifluoride Varnish</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>Control</td>
<td>Experimental</td>
</tr>
<tr>
<td>1</td>
<td>30.01</td>
<td>111.46</td>
<td>18.43</td>
</tr>
<tr>
<td>2</td>
<td>48.8</td>
<td>58.82</td>
<td>31.20</td>
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<td>3</td>
<td>94.31</td>
<td>107.18</td>
<td>15.45</td>
</tr>
<tr>
<td>4</td>
<td>48.8</td>
<td>64.45</td>
<td>27.11</td>
</tr>
<tr>
<td>5</td>
<td>46.17</td>
<td>51.62</td>
<td>21.80</td>
</tr>
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<td>6</td>
<td>21.43</td>
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<tr>
<td>9</td>
<td>73.38</td>
<td>98.60</td>
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</tr>
<tr>
<td>10</td>
<td>34.29</td>
<td>94.41</td>
<td>43.70</td>
</tr>
<tr>
<td>11</td>
<td>47.15</td>
<td>55.73</td>
<td>40.67</td>
</tr>
<tr>
<td>12</td>
<td>30.01</td>
<td>64.45</td>
<td>17.07</td>
</tr>
</tbody>
</table>

Table 2: Comparison of depth of demineralization in enamel between the experimental and control samples of all the groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>Sample</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Std. error mean</th>
<th>p-value</th>
<th>Percentage reduction in lesion depth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transbond Plus</td>
<td>Experimental</td>
<td>21.43</td>
<td>94.31</td>
<td>43.36</td>
<td>22.02</td>
<td>6.35</td>
<td>p &lt; 0.05</td>
<td>43.3</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>51.62</td>
<td>111.46</td>
<td>76.55</td>
<td>21.01</td>
<td>6.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GC Tooth Mousse</td>
<td>Experimental</td>
<td>0.00</td>
<td>43.70</td>
<td>24.03</td>
<td>11.72</td>
<td>3.82</td>
<td>p &lt; 0.05</td>
<td>67.45</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>34.3</td>
<td>107.5</td>
<td>73.81</td>
<td>26.72</td>
<td>7.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bifluoride Varnish</td>
<td>Experimental</td>
<td>15.45</td>
<td>51.62</td>
<td>27.32</td>
<td>10.75</td>
<td>3.10</td>
<td>p &lt; 0.05</td>
<td>70.06</td>
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<tr>
<td></td>
<td>Control</td>
<td>51.60</td>
<td>124.99</td>
<td>91.28</td>
<td>23.33</td>
<td>6.73</td>
<td></td>
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</tr>
</tbody>
</table>

Together with fluoride applications, the development and use of fluoride-releasing orthodontic materials may reduce the risk of enamel demineralization during orthodontic treatment. Fluoride works primarily via topical mechanisms described as a reduction in the rate of dissolution in the demineralization phase in acidic conditions, the enhancement of remineralization at the crystal surface, and the inhibition of bacterial enzymes.6-8

In this study, homologous premolars to be extracted for orthodontic purposes were used. In this way, each patient had an internal control. This is an important aspect since caries susceptibility is known to differ strongly between patients.

The other methods of observing WSLs, such as quantitative laser fluorescence9,10 only allow us to diagnose them, whereas this in vivo study permits the evaluation of enamel demineralization all along the buccal surface of the tooth even if the lesions are not visible to the naked eye. Furthermore, the microscopic analysis with the help of polarized light allows accurate identification of not only the lesion but also the depth and extent of the lesion can be measured.3

Transbond PLUS Color Change Adhesive and Bifluorid 12 varnish were free of patient compliance and were applied by the operator at the time of bonding the brackets. Since the duration of the study was only for 3 months, the varnish was applied once around the experimental teeth. The material that required patient compliance was GC Tooth Mousse Plus since it was a home application.

Fluoride-releasing adhesives have been shown to release fluoride actively for a period of 60 to 90 days. Calcium fluoride-like particles are present on the enamel surface where the fluoride-releasing adhesive systems are used.11 Dissociation of fluoride ions from calcium fluoride crystals and diffusion into the pores in the enamel occurs, either during the initial intense release or later during the slow but regular exposure to fluoride. Therefore, although the fluoride release from the adhesive is limited for a short period of time, the action of fluoride continues and offers protection...
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Graph 1: Comparison of depth of enamel demineralization among the experimental groups

Graph 2: Comparison of depth of enamel demineralization among control samples of the three groups

to the enamel. The fluoride release from Transbond Plus material is comparable to other fluoride-releasing adhesives and is about 500 μg/day/gm of material. The rate of fluoride release decreases by the day with an initial level of 0.0073 μg/cm²/d of sample disks as seen in an in vitro study. There was found to be a 43.3% reduction in the lesion depth in the experimental samples as compared with the control samples of the fluoride-releasing adhesive group in this study.

A fluoride varnish delivers fluoride ions to the enamel at the peripheral margins of the varnish. Fluoride ions from the varnish can join calcium and phosphorous ions from the saliva and enamel inside the pellicle and become incorporated into the enamel surface. The advantage with fluoride varnish is that the application of the material takes a small amount of chair side time and eliminates the need for patient compliance and can also be accomplished by staff personnel. In this study, there was 70% reduction in the lesion depth as against the controls in the group, where bifluoride varnish was used.

The need for the development of a nontoxic, anticariogenic agent that could supplement the effects of fluoride in an attempt to further lower caries incidence has been highlighted in recent years. Casein phosphopeptide-acidulated calcium phosphate (CPP-ACP) is an anticariogenic agent newly derived from milk production. GC Tooth Mousse Plus was the third material that was used. There was significant decrease in the enamel lesion depth when compared to the control teeth and the reduction in demineralization depth was 67.4% in the CPP-ACP experimental group.

DRAWBACKS OF THE STUDY

1. Only patients requiring extractions can participate and hence only premolar teeth are tested.
2. This experiment is confined to the initial stages of treatment, usually the first 2 to 3 months, whereas orthodontics can take up to 2 years. This technique is, therefore, unable to monitor changes in the enamel throughout the duration of the treatment. There may also be a longer time for treatment effects.
3. The level of demineralization before commencing treatment has not been assessed only clinically and later with the help of microscopy, both of which have varied levels of accuracy.
4. The location of the lesion cannot be standardized mesiodistally in the sections made in this method.
5. Validity—It is often difficult clinically to distinguish white spots caused by demineralization and those that are due to other causes, such as developmental hypoplasia or fluorosis.

CONCLUSION

The following conclusions can be drawn from this in vivo study:

- WSLs are regular occurrences caused by enamel demineralization around brackets in almost all orthodontic patients as oral hygiene becomes challenging in them.
- Enamel demineralization around brackets is significantly reduced by all the three materials used in this study, that is, Transbond PLUS Color Change Adhesive, bifluoride varnish and GC Tooth Mousse Plus.
- Transbond Plus, although effective in preventing WSLs to a significant extent, was the least effective among the three materials used.
- Although patient compliance was reasonably good in this in vivo study which was proven by the reduction of lesion depth in the GC Tooth Mousse group, it is a factor to be borne in mind while preventing WSLs especially in young children and adolescents who form the majority of orthodontic patients.
• The highest amount of lesion depth reduction was seen in the bifluoride varnish group with a reduction of demineralization depth by 70.06%.

MANUFACTURERS

1. Transbond PLUS Color Change Adhesive (3M UNITEK, Monrovia, California).
2. Bifluorid 12 varnish (VOCO, Cuxhaven, Germany).

REFERENCES