Fluoride Released from Orthodontic Bonding Material: An In Vitro Evaluation

SUMMARY

Enamel demineralization is an undesirable but common complication of orthodontic fixed appliances therapy. The purpose of this study was to test long-term benefits of resin-modified glass ionomer cement (GC Fuji Ortho™ LC) for the prevention of demineralization in patients receiving orthodontic treatment with fixed bonded appliances.

90 healthy extracted premolars without any clinical signs of decalcification were selected. All teeth were cleaned and cut in half buccolingually with a diamond disc. Thus, the control and test specimens were obtained from the same teeth. Orthodontic brackets were bonded with a resin-modified glass ionomer cement. The teeth were divided in 3 groups according to the period of monitoring (1, 3 and 6 months). They were stored in artificial saliva until analyzing. Determination of the fluoride in enamel was done by spectrophotometer.

The amount of fluoride in enamel 1 month after the brackets application was significantly higher; after 3 months it was even higher; and after 6 months it was still statistically significantly higher compared to initial values, but lower than the previous 2 time intervals (and remained on a constant level). The results of this in vitro study clearly indicate that fluoride-releasing material used in fixed orthodontic treatment inhibits demineralization of enamel around orthodontic appliances.

Keywords: Enamel; Brackets; Glass-ionomer Cements; Demineralization; Remineralization

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Introduction

Orthodontists are still challenged by an “old problem” in their practices: enamel demineralization around orthodontic appliances. Patients undergoing orthodontic therapy are exposed to a higher risk of enamel demineralization1. Appliances are directly attached to tooth surface, increasing the difficulty of achieving adequate oral hygiene. Some of commonly used accessories, such as hooks, posts, elastic chains and springs, can also undermine dental bio-film removal. Thus, the incidence of white spot lesions can be significantly higher among orthodontic patients with poor oral hygiene6.

Enamel demineralization is an undesirable but common complication of orthodontic fixed appliances therapy. Several studies have reported a significant increase in the prevalence and severity of demineralization after orthodontic therapy compared with controls, and the overall prevalence amongst orthodontic patients ranges from 2 to 96%17,19. The teeth most commonly affected are molars, maxillary lateral incisors, mandibular canines and premolars15.

The potential risk of enamel surface decalcification during orthodontic treatment can be reduced by using glass ionomer cements (GIC) for bonding the brackets2-4. GIC have been showed to consistently release fluoride over time. They also have ability to take up and re-release fluoride after application of a topical fluorides source. Although the property of fluoride releasing would appear to make GIC an ideal bonding agent for orthodontic brackets, the adequacy of strength for successful clinical bonding9,12,24 is less. Recently, Fuji Ortho™ LC developed the GIC for bonding brackets to teeth. The manufacturer claims it can be applied in a wet field and is not as technique-sensitive as composite resins.
Specifically, it requires no etching of the enamel surface and should be applied in wet environment. Another attribute of glass ionomers is that they release fluoride, which is known to reduce the incidence of caries\textsuperscript{13,22}. The process of fluoride release is by way of polyacid attack on the alumino-silicate glass. As the glass network breaks down, the Al\textsuperscript{3+}, Ca\textsuperscript{2+}, and F\textsuperscript{3+} ions are released\textsuperscript{21}.

The capacity of glass ionomers to absorb fluoride from rinses and tooth paste in essence allows the glass ionomer to reconstitute itself and continuously release fluoride. This should aid in the decreased incidence of decalcification and unsightly white spots around the brackets. The advantages proposed to be gained by the operator and patients are substantial. If all these factors were true for the new Fuji Ortho\textsuperscript{TM} LC product, it would be more beneficial clinically than composite resin alone. Because of these possible improvements over composite resin, a test of Fuji Ortho\textsuperscript{TM} LC effectiveness in lowering bracket failure rate and incidence of decalcification seemed in order\textsuperscript{5,10}.

Cook\textsuperscript{6} compared the in vivo bond strength of GIC Ketac (ESPE Premier Denbol Products), with a composite resin bonding agent. The result of his evaluation indicated that the bond strength of that GIC was not nearly as good as that of the composite resin. Cook stated that thorough drying of the teeth before GIC use was not necessary, but that cotton rolls should be used to isolate the field of operation. He also suggested that the surface of the teeth to be bonded should be wiped off before bracket placement and stressed that acid etching was not necessary. The 40 cases studied showed a 12% failure rate, which is considered too great for routine orthodontic practice.

Fajen et al\textsuperscript{11} evaluated the bond strength of 3 different GIC against a composite resin in vitro, and like Cook, found the bond strength of the GIC to be “significantly less”. The fluoride release is a result of 2 processes: the short-term release is associated with a leakage of relatively loosely bound fluoride from the cement matrix. The long-term release is a result of diffusion controlled phenomena where the concentration gradient is the moving force for the release.

The purpose of this study was to test the long-term benefits of resin-modified GIC (GC Fuji Ortho\textsuperscript{TM} LC) for prevention of demineralization in patients receiving orthodontic treatment with fixed bonded appliances.

### Material and Method

In this study, 90 healthy extracted premolars without any clinical signs of decalcification were selected. All teeth were cleaned and cut in half bucco-lingually with a diamond disc. Thus, the control and test specimens were obtained from the same teeth. Orthodontic brackets were bonded with GC Fuji Ortho\textsuperscript{TM} LC, resin-modified GIC. The teeth were divided in 3 groups according to the period of monitoring (1, 3 and 6 months). They were stored in artificial saliva (20 mmol/l NaHCO\textsubscript{3}, 3 mmol/l NaH\textsubscript{2}PO\textsubscript{4} and 1 mmol/l CaCl\textsubscript{2}, neutral pH) until analyzing. Determination of the fluoride in enamel was done by spectrophotometer. Determination started with distillation, and then 50ml of the distillate was mixed with 10ml SPADNS and acidic circonyl. The absorbance was read on the spectrophotometer. Than the results were calculated by the formula: 

\[
F \text{ ppm} = \frac{50 \times A}{V}
\]

where A is ppm of fluoride measured by the spectrophotometer, and V ml of the sample.

For statistical evaluation, a one-way analysis of variance (ANOVA) was initially used to see if there was a significant difference between groups. Results

Table 1 shows the value of F in enamel in the experimental group of teeth 1 month after brackets were bonded. Average value of F in the examined group of teeth was 844,044 ppm, and in the control group of teeth the average value of F was 614,230 ppm. For this time period, a statistically significant difference was found between values of F in the examined groups of teeth.

**Table 1. Values of F (ppm) in enamel 1 month after bonding brackets**

<table>
<thead>
<tr>
<th>group</th>
<th>N</th>
<th>X</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>test</td>
<td>30</td>
<td>844,044</td>
<td>314,130</td>
<td>3,490</td>
<td>0,00085*</td>
</tr>
<tr>
<td>control</td>
<td>30</td>
<td>614,230</td>
<td>177,159</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 shows the values of F in enamel in the group of examined and control teeth 3 months after bonding of brackets. Again, a statistically significant difference was found between values of F in the examined and control group of teeth, respectively.

**Table 2. Values of F (ppm) in enamel 3 months after bonding brackets**

<table>
<thead>
<tr>
<th>group</th>
<th>n</th>
<th>X</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>test</td>
<td>30</td>
<td>946,260</td>
<td>449,995</td>
<td>2,462</td>
<td>0,01672*</td>
</tr>
<tr>
<td>control</td>
<td>30</td>
<td>684,072</td>
<td>370,822</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 shows the values of F in enamel in the group of examined and control teeth 3 months after bonding of brackets. Again, a statistically significant difference of the values was found (946,260 ppm and 684,072 ppm of F in the examined and control group of teeth, respectively).
Values of the F in enamel of the examined and control group of teeth 6 months after bonding brackets are presented in table 3. The result was similar to the previous. After treatment of 1, 3 and 6 months, statistically significant difference occurred in the average values of fluoride in enamel between the experimental and control groups. The differences were greater after 1 month and smaller after 6 months (Tab. 4).

### Table 3. Values of F (ppm) in enamel 6 months after bonding brackets

<table>
<thead>
<tr>
<th>group</th>
<th>n</th>
<th>X</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>test</td>
<td>30</td>
<td>557,398</td>
<td>198,477</td>
<td>2.076</td>
<td>0.04438*</td>
</tr>
<tr>
<td>control</td>
<td>30</td>
<td>454,539</td>
<td>185,117</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4. Comparative display of F values in enamel at the test and control group

<table>
<thead>
<tr>
<th>group</th>
<th>n</th>
<th>tame/ months</th>
<th>X</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>test</td>
<td>30</td>
<td>1</td>
<td>844,044</td>
<td>314,130</td>
<td>3,490</td>
<td>0.00085*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>946,260</td>
<td>449,995</td>
<td>2,462</td>
<td>0.01672*</td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

## Discussion

After completing the fixed orthodontic treatment, and as a reason that ideal oral hygiene usually is not achieved, demineralised zones are spotted. They are more noticed in the gingival part of labial surface of the teeth, where plaque accumulation is significantly higher. Such demineralised zone appears as early as 4 weeks after orthodontic brackets and bands placement. It is known that these demineralised zones are able to remineralise and to restore the damaged apatite crystals. The process of remineralisation in the oral cavity is favoured by fluoride. This effect is one of the reasons why application of fluoride is recommended every time to prevent, neutralise or restore demineralised enamel (with good oral hygiene). Its crystals are larger than the original ones, which is linked to the reducing possibility of dissolving. This explains the positive cariostatic effect of materials containing fluoride used for bonding the brackets. Around some brackets bonded with such materials, due to the released fluoride, a weaker demineralization of enamel appears than in cases where they are bonded with materials which do not release fluoride.

Results of this study clearly show that the content of fluoride in enamel significantly increased after application of GIC containing fluoride. Thus, the amount of fluoride in enamel before fixing the brackets was 614,230 ppm; after 1 month of their bonding, the amount of fluoride in enamel was 844,044 ppm, which is statistically significantly higher of the initial coverage of fluoride in enamel. After 3 months, the value of fluoride in enamel in the examined group was even higher (946,260 ppm). After 6 months decrease the amount of fluoride (557,398 ppm) was noticed, although still significantly higher compared to the control group.

In our study enamel demineralization in vitro was inhibited to a certain degree. Similar prevention of decalcification was reported by many authors for other fluoride-releasing materials. Besides the positive impact on local fluoride-released cement used for bonding the brackets in inhibiting demineralisation of the enamel around orthodontic brackets and bands, the release of fluoride from GICs provides continuous presence of low concentrations of fluoride in the oral medium, which also influence with inhibition on demineralised enamel around orthodontic brackets and bands.

## Conclusions

The fluorides contribute to inhibition of demineralization process around the brackets and bands during fixed orthodontic treatment. The amount of fluoride in enamel after 1 month after the brackets application was significantly higher, after 3 months it was higher, and after 6 months it was still statistically significantly higher compared to initial values; yet it is still lower than the previous 2 time intervals (and remains on a constant level).

The results of this in vitro study clearly indicate that fluoride-releasing materials used in fixed orthodontic treatment inhibit demineralization of enamel around orthodontic appliances.

## References


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