THE EFFECT OF VARIOUS DENTAL FILLING MATERIALS ON ARTIFICIALLY DEMINERALIZED DENTIN

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Abstract: The aim of this study was to determine the influence of fluoride, released by all of the restorative materials in the process of remineralization. To achieve this, we measured the concentration of the incorporated fluoride and calcium in dentin.

The research was done on 80 extracted third molars, in which we prepared first-class cavities. After the process of decalcination, we split the teeth into four different groups (with 20 in each). The teeth from each group were separated vertically, in two halves. On the experimental half we applied the examined material (Fuji IX, Fuji Lining LC, G Bond and Prime&Bond) and we used the other half as a control. Later, the specimens were put into a glass bowl together with remineralization solution and were incubated at a temperature of 37°C. The incorporated fluoride and calcium concentration was determined by a significant increase of spectrometer.

After applying the specimens in a remineralization solution, we perceived that the level of incorporated Ca²⁺ on the teeth restored with Fuji IX & Fuji Lining LC was significantly higher compared to the level of incorporated Ca²⁺ on the teeth, restored with dentin materials. Based on the results from this experiment, the conclusion shows that fluoride, released from the materials and incorporated into the dentin, speeds up the process of remineralization on hard dental tissues.

Key words: fluoride, calcium, remineralization, dentin.
Introduction

The incorporation of fluoride into restorative materials is one way of inhibiting growth and progress of cariogenic microorganisms, of preventing carious diseases and a way of stimulating the process of remineralization of dentin after restorative filling [15].

Glass ionomer cements are restorative materials which contain and release fluoride over a long time period [2, 3, 5]. The resistance of dentin to the occurrence of secondary caries in restorations with conventional and light curing glass ionomer cements has been determined by a few researches [9, 17]. In the last few years composite resins, adhesives and bonds which contain and release fluoride have also been in use [18]. Most of the fluoride released from the restorative materials is incorporated into the surrounding enamel and dentin, especially in those parts which are in direct contact with the restoratives, and makes them more resistant to cariogenic factors [1, 12]. Deposition of fluoride in different restorative materials can vary and depends primarily on the amount of fluoride released by these materials [7, 8]. Both fluoride released from the filing material and fluoride present in saliva, along with calcium and phosphate ions, are incorporated in demineralized dentin and enamel [4].

During this, a crystal enamel and dentin structure is formed, which contains more fluoride and less carbonate and is much more resistant to acids. While some studies suggest increased mineralization of dentin and enamel after application of restorative materials containing fluoride, other studies show that remineralization on both enamel and dentin can occur after application of the universal bond which does not contain fluoride, in the presence of calcium and phosphate ions [10, 11].

Aim

After the above, the aim of this study was to determine the influence of restorative materials on the process of remineralization by measuring the level of incorporated fluoride and calcium in the dentin.

Material and method

The concentration of fluoride and calcium in dentin was determined on the extracted third molars. After extraction of teeth the soft tissues were removed and the crowns were separated from the roots. In all teeth we made first class cavities with the bottom of the cavities in the dentin. For decalcination of dentin we used 150 ml, 0,1M lactic acid with pH 4, 6. Earlier prepared dental
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crowns were put in glass containers with the surface above and through them we applied 8% methylcellulose gel. After 24 hours we set a filter paper through the gel and through it we applied the solution for decalcination. The containers were closed and the samples were incubated at a temperature of 37°C for a seven day period. After decalcination, the dental crowns were divided into four equal groups of 20 crowns.

Crowns from each group were separated vertically in halves and from each group were formed 2 subgroups A and B.

On the halves of the A subgroups we applied the researched materials and the halves from the B subgroups were used as a control sample group. Later, each of the examined samples was put in a glass bowl with remineralization solution and was incubated at 37°C. The remineralization solution that was prepared \textit{ex tempore} was composed of: 1.5 mmol/l CaCl\textsubscript{2}, 0.9 mmol/l KH\textsubscript{2}PO\textsubscript{4}, 130 mmol/l KCl, 0.1 ppm NaF and 20 mmol/l, HEPES with pH 7.0. After 3 weeks all of the tested samples were removed from the remineralization solution. In the teeth of the examined groups we removed the tested material, separated the crown enamel from the dentin and prepared the teeth to determine the concentration of fluoride and calcium. The concentration of fluoride and calcium was determined spectrometrically following the modified method described by Quentin KE [16]. The obtained results from all trials were statistically analysed using descriptive and analytical statistical methods: mean minimum, max, rank, standard deviation, standard error, median, proportions, LSD test, and Prison’s coefficient of linear correlation and student t-test for two bound copies. The levels of probability of achieving the zero hypotheses are 0.05 and 0.01. The overall statistical analysis was done using a computer statistical programme from the Institute of Medical Statistics at the Medical Faculty in Belgrade.

Results

The results of measurements of the amount of fluoride incorporated into dentin showed that in the case of Fuji IX, Fuji Lining LC and Prime&Bond there is a statistically highly significant difference in average values of fluoride between examined and control groups. For a period of three weeks the greatest incorporation of fluoride in dentin was noticed after applying Fuji IX, Fuji Lining LC and Prime&Bond, while the teeth restored with G Bond showed a statistically insignificant amount of fluoride (Tab. 1).

Middle values of incorporated calcium are given in Tab 2. While measuring the concentration of calcium, ANOVA the numerical characteristics of observation have shown that $p < 0.01$, which leads us to the fact that there is a
statistically highly significant difference in the average calcium values among the tested and control groups after a period of 3 weeks.

Table 1

Concentration of incorporated fluoride in dentine, 3 weeks after applying material

<table>
<thead>
<tr>
<th></th>
<th>FLLC</th>
<th>FIX</th>
<th>GB</th>
<th>P&amp;B</th>
</tr>
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<tbody>
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<td>.2143</td>
<td>0.0399</td>
<td>0.0990</td>
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<tr>
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<td>.2027</td>
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<td>.0692</td>
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<tr>
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<td>.0112</td>
<td>.0201</td>
</tr>
<tr>
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<td>.0035</td>
<td>.0045</td>
<td>.0082</td>
</tr>
<tr>
<td>median</td>
<td>.1693</td>
<td>.2143</td>
<td>.0416</td>
<td>.0990</td>
</tr>
</tbody>
</table>

Table 2

Concentration of incorporated Ca in dentin (µg Ca/mg), 3 weeks after applying the material

<table>
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<th>GB</th>
<th>P&amp;B</th>
</tr>
</thead>
<tbody>
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<td>1.9922</td>
<td>1.0236</td>
<td>1.2132</td>
</tr>
<tr>
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<td>1.1944</td>
<td>.9758</td>
<td>1.0826</td>
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<tr>
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<td>.0969</td>
<td>.2613</td>
</tr>
<tr>
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<td>.5141</td>
<td>.0339</td>
<td>.0439</td>
</tr>
<tr>
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<td>.0439</td>
</tr>
<tr>
<td>median</td>
<td>1.9502</td>
<td>1.9924</td>
<td>1.0233</td>
<td>1.2132</td>
</tr>
</tbody>
</table>

The amount of incorporated calcium among groups restored with Fuji IX & Fuji Lining LC was significantly larger than the amount of calcium incorporated in the groups restored with G Bond, Prime&Bond. There is no statistical significant difference in the amount of incorporated Ca between the samples restored with G Bond, Prime&Bond.

When comparing the amount of incorporated fluoride with the amount of incorporated calcium in dentin, after a period of 3 weeks Prison’s coefficient of liner correlation showed a statistically highly significant positive correlation, p < 0.01 (Fig. 1).
The aim of this study was to determine the influence of fluoride on the remineralization potential of four restorative materials. For this research we used dentin, because the examined materials are applied directly on dentin and the sensitivity of dentin is higher compared with that of enamel. Dentin is more sensitive to the action of acids, it demineralises faster than enamel and the process of remineralization is also faster. The incorporation of fluoride is a dynamic process in correlation with the amount of fluoride released from the restorative material. The results obtained from this study showed that three weeks after applying the restorative material, the amount of incorporated fluoride was highest among the samples restored with Fuji IX, and lowest in the teeth treated with Prime&Bond. The group of teeth restored with G Bond showed a statistically insignificant difference between the experimental and control groups. The research of several authors shows that the amount of incorporated fluoride in dentin after application of conventional glass ionomer cements was significantly larger compared with the amount of incorporated fluoride after the application of resin-modified glass ionomer cements, compomers or composite resins [6, 13].

Tsangalis believes that, despite small differences, the amount of incorporated fluoride between the two glass ionomer cements does not differ significantly [20]. The difference in the amount of incorporated fluoride between glass
Ionomer cements and dentin adhesives is due to the fact that dentin adhesives are applied in a thin layer and glass ionomer cements in greater quantity [8]. There are few studies confirming the remineralization effect of fluoride-releasing restorative materials [15]. In our study we also examined the deposition of calcium ions in dentine after restoration with Fuji IX, Fuji lining LC, G Bond, Prime&Bond, after a period of 3 weeks. The groups restored with glass ionomer cements showed the largest deposition of Ca ions in dentin. The deposition of Ca ions in the groups treated with dentin adhesives was significantly lower. There was no significant difference in the amount of incorporated calcium in dentin between the two studied glass ionomer cements and two dentin adhesives. According to test made by Extercate, fluorides released from glass ionomer cements together with calcium and phosphate ions diffusing from the pulpal side may result in enhanced remineralization of demineralised dentin close to the restoration. No differential effect on overall lesion remineralisation could be measured between the conventional and resin-modified glass ionomer cement [6]. Hotta’s research shows that increased mineralization occurs only in the high fluoride-release filling materials (glass ionomer cements) [11]. However, increased mineralization did not occur in the case of the low fluoride-release filling materials.

Tominaga considers that there is no significant difference in the level of remineralization between glass ionomer cements and composites [19]. Remineralization of a carious lesion may occur after application of the universal bond in the presence of calcium and phosphate ions. According to these researchers, the presence of fluoride correlates positively with the process of remineralization, which has been proved by the results from our research [4].

When comparing the amount of incorporated fluoride with the amount of incorporated calcium, we received a positive correlation for all of the researched groups. This leads us to the fact that in the materials where the incorporation of fluoride was larger, the incorporation of calcium was also larger. Contrary to the results presented in this study, Marczuk-Kolada could not detect an increase in the level of calcium after applying Fuji IX [14].

**Conclusion**

Based on the results from our research we came to the conclusion that fluoride, released from restorative materials and incorporated into adjacent dentin, accelerates the process of remineralization of hard dental tissues.
REFERENCES


Резиме

ЕФЕКТОТ НА РАЗЛИЧНИ МАТЕРИЈАЛИ ЗА РЕСТАВРАЦИЈА ВРЗ АРТЕФИЦИЈЕЛНО ДЕМИНЕРАЛИЗИРАН ДЕНТИН

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Апстракт: Целта на овој труд е да го одредиме влијанието на флуорот ослободен од материјалите за реставрација врз процес на реминерализија, преку мереже на концентрацијата на инкорпориран флуор и калциум во дентин.

Материјал и метод: Испитувањето го правевме на 80 екстрактирани трети молари, куј кои исправиравме капитети прва класа. По декалицирањето забитите коронки ги поделивме во четири еднакви групи од по 20 коронки. Коронките од секоја група ги сепарирале вертикално на половини при што на едната половина го аплицирахме матерijалот кој го испитувањето (Fiji IX, Fuji Lining LC, G Bond и Prime&Bond), а другата половини ни служеше како контролна. Потоа секоја група испитувани и контролни примерци ги ставивме во стаклен сад со раствор за реминерализија и ги
инкубираме на температура од 37°C. Концентрацијата на калциум и флуор ја одредуваме спектрофотометриски.

Резултати: Најголема концентрација на инкорпориран флуор од 0,214 µg/mg забележавме кај примерците третирани со Fuji IX, а најмала кај групата на Prime&Bond. По апликација на примерците во раствор за реминерализација количината на инкорпориран калциум кај забите реставрирани со Fuji IX и Fuji Lining LC беше значително повисока споредено со количината на инкорпориран калциум кај примерците реставрирани со дентин атхези. 

Заклучок: Врз основа на резултатите што ги добивме во ова истражување можеме да заклучиме дека флуорот што се ослободува од материјалот за реставрација и се инкорпорира во соседните забни структури го забрузува процесот на реминерализација на тврдите забни ткива.

Ключни зборови: флуор, калциум, реминерализација, дентин.