ANALYSIS OF FLUORIDE RELEASED FROM GIC AND RMGIC IN SALIVA AND DENTINO-ENAMEL SUBSTANCE

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Abstract

Background: Glass Ionomer Cement (GIC) and Resin Modified Glass Ionomer cement (RMGIC) are two of the restorative materials in dentistry that have the capacity of releasing fluoride to saliva, dentino-enamel substance and also the ability to form fluorapatite crystal. Objective: The aim of this study was to compare the amount of fluoride release in saliva and dentino-enamel substance. Material and Methods: a total of 48 caries free premolar teeth were prepared to form a cavity with the dimension of 4 X 4 X 2 mm on the buccal surfaces. These teeth were then divided into 3 groups, each containing 16 samples. The first group was determined as the control group and therefore no restorative material was applied to the teeth in this group; the teeth in the second group were filled with GIC, the third group was filled with RMGIC. These teeth were then soaked in artificial saliva without fluoride content and were incubated at room temperature (37 degrees Celcius). Each group was divided again into 4 sub groups, each consisted of 4 samples. Each of 4 subgroups received different periods of soaking, namely 1 day, 3 days, 10 days and 20 days. The fluoride content of saliva was analyzed using ion chromatography, and fluorapatite on dentino-enamel substance was analyzed using X-Ray Diffraction or XRD. Data obtained from the experiments were analyzed using ANOVA and the level of significancy level was set at $P \leq 0.05$. Result: There was significant difference in the analysis of fluoride release in saliva within the 3 groups: GIC, RMGIC and the control group, and there was no significant difference in the analysis of fluoroapatite formation on dentino-enamel substance within 3 groups. Conclusion: The amount of fluoride content in saliva showed significant difference within the 3 groups of GIC, RMGIC and control. No significant difference was found in the fluorapatite content on dentino-enamel substance.

Keywords: fluoride, GIC, RMGIC, saliva, dentino-enamel.

Introduction

Glass ionomer Cement (GIC) is an adhesive esthetic restorative material, found by Wilson and Kent in 1971, which consists of fluoride-rich calcium fluoroaluminosilicate glass powder, and polyalenoic acid which contains polyacrilic acid with carboxyl chains \(^{1,2,3}\). The disadvantage of GIC lies on its translucency, hardness, and strength which contribute to its susceptibility to fracture and less esthetic result \(^{1,2,4-10}\). Due to these disadvantages, numerous manufacturer developed a new GIC which was modified by resin component, later known as Resin Modified Glass Ionomer Cement (RMGIC). The modifications were apparent on its liquid component which was added by a photosensitive material called the hydroxyethyl metacrylate monomer (HEMA), and on its powder component which was added by resin matrix to further enhance the strength, hardness, and translucency of this new material \(^9,^{11}\).
Fluoride release of GIC dan RMGIC is merely an ion changing reaction and not an integral part of matrix cement, thus the fluoride release may not be harmful to its physical properties. The amount of released fluoride from the GIC or RMGIC restorative materials will cause the emergence of other effects, such as the adherence and penetration to tooth structure followed by substitution of hydroxyl chains, and alteration of hydroxyapatite crystal into fluoroapatite crystal. In addition, it also promotes remineralization. The formation of fluoroapatite crystal will increase tooth resistance to caries attack and inhibit bacterial synthesis that can discourage plaque accumulation on the surface of the restoration. Long-term release of fluoride ion from GIC and RMGIC has always been considered as one of its advantage, where the peak of its fluoride release occurs at initial setting and decreasing rapidly within the first 1 to 2 months and finally arrives at its stabil rate, showing low amount yet constant release of fluoride. This may be demonstrated in a study, conducted to measure the amount of fluoride release from GIC in artificial saliva. This study revealed that the amount of fluoride ion released in the artificial saliva within the first 24 hours was around 5 – 155 ppm, and decreased gradually until it reached its constant rate 10 – 20 days later, whereas in RMGIC, there was less amount of fluoride release, even though at the end of the study, both of those restorative material showed the same amount of fluoride release in time. Other authors stated that fluoride release from GIC may lasts up to 5 years. In addition, there are other authors who found out that fluoride release from the RMGIC occurred only for 800 days. In a study that compared the amount of fluoride released from the GIC and RMGIC in saliva, it was demonstrated that GIC released higher amount of fluoride compared to RMGIC.

![Figure 1. Fluoride release from glass ionomer cement.](image)
Since most studies used only pure GIC and RMGIC specimens, we used GIC and RMGIC that were filled into cavities prepared in human premolar teeth as samples in our study, in order to resemble the natural settings of clinical condition so that the result obtained in this study might be clinically implemented. The amount of released fluoride ion from GIC and RMGIC in saliva, and the formation of fluoroapatite crystal in enamel – dentin structure were analyzed and compared to one another in different periods.

**Materials and methods**

Premolars teeth that are free of caries and other hard surface deformity which has been extracted for orthodontic purpose, are used in this research. The teeth were soaked in saline solution to preserve its humidity. A total of 48 premolar teeth were prepared to form a cavity on the buccal surface, with the cavity dimension of 4 X 4 X 2 mm. These teeth were then divided into 3 groups, each containing 16 samples. The first group was determined as the control group and therefore no restorative material was applied to teeth in this group; the teeth in the second group were filled by GIC, the third group was filled by RMGIC. These teeth were then soaked in artificial saliva without fluoride content and were incubated at room temperature (37 degrees Celscius). Each group was further divided into 4 subgroups, each consisted of 4 samples. Each of the 4 subgroups received different periods of soaking, namely 1 day, 3 days, 10 days and 20 days. The fluoride content of saliva was analyzed using ion chromatography, while the dentino-enamel structures were collected by using diamond bur analyzed using X-Ray Diffraction or XRD. Data obtained from the experiments were analyzed using ANOVA and the level of significance level was set at $P \leq 0.05$.

![Fluoride movement cycle from GIC](image.png)
**Result**

**Tabel.1: Description of fluoride value in artificial saliva**

<table>
<thead>
<tr>
<th></th>
<th>GIC</th>
<th>RMGIC</th>
<th>Control</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(40)</td>
<td>(40)</td>
<td>(40)</td>
<td>(120)</td>
</tr>
<tr>
<td>1 day</td>
<td>9,18(2,62)</td>
<td>2,01(0,81)</td>
<td>0,07(0,08)</td>
<td>3,75(4,26)</td>
</tr>
<tr>
<td>3 days</td>
<td>0,52(0,20)</td>
<td>0,22(0,14)</td>
<td>0,00(0,00)</td>
<td>0,25(0,26)</td>
</tr>
<tr>
<td>10 days</td>
<td>0,33(0,13)</td>
<td>0,07(0,03)</td>
<td>0,00(0,00)</td>
<td>0,13(0,16)</td>
</tr>
<tr>
<td>20 days</td>
<td>0,05(0,02)</td>
<td>0,05(0,03)</td>
<td>0,00(0,00)</td>
<td>0,04(0,03)</td>
</tr>
</tbody>
</table>

Note:
GIC = Glass Ionomer Cement, 
RMGIC = Resin Modified Glass Ionomer Cement, 
(40) = n, 9 
18 = mean 
(2,62) = standard deviation.

**Tabel.2: p-value of fluoride in artificial saliva**

<table>
<thead>
<tr>
<th></th>
<th>1dvs3d</th>
<th>1dvs10d</th>
<th>1dvs20d</th>
<th>3dvs10d</th>
<th>3dvs20d</th>
<th>10dvs20d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>GIC</td>
<td>0,000*</td>
<td>0,000*</td>
<td>0,000*</td>
<td>1,000</td>
<td>0,982</td>
<td>1,000</td>
</tr>
<tr>
<td>RMGIC</td>
<td>0,001*</td>
<td>0,000*</td>
<td>0,000*</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Note: d=day, GIC=glass ionomer cement, RMGIC=resin modified glass ionomer cement 
P value ≤ 0,05

The amount of fluoride release in saliva on day 1 compared to that of day 3, 10 and 20 within the control groups showed no significant difference. This demonstrated that there were no fluoride ions released from the tooth structure. In GIC and RMGIC groups, there were significant differences in the amount of fluoride release in saliva measured on the first day, compared to that of day 3, 10, and 20. Comparison of fluoride content in saliva of day 3, with that of day 10 and 20 revealed no significant difference.

**Tabel.3: Comparison of p-value of fluoride in artificial saliva**

<table>
<thead>
<tr>
<th></th>
<th>Control Vs GIC Vs RMGIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day</td>
<td>0,000*</td>
</tr>
<tr>
<td>3 days</td>
<td>0,000*</td>
</tr>
<tr>
<td>10 days</td>
<td>0,000*</td>
</tr>
<tr>
<td>20 days</td>
<td>0,000*</td>
</tr>
</tbody>
</table>

Note: GIC= Glass Ionomer Cement, RMGIC= Resin Modified Glass Ionomer Cement. 
p ≤ 0,05
The value of fluoride contained in the artificial saliva showed significant difference in all groups of different soaking periods.

By viewing the boxplot illustrated above, it is obvious that the highest amount of fluoride release occurs at the first day of the GIC group, followed by first day of the RMGIC groups, and it showed that there were difference in significance rate due to the absence of overlapping illustration.

The fluoroapatite value in dentino-enamel substance

<table>
<thead>
<tr>
<th>GIC (40)</th>
<th>RMGIC (40)</th>
<th>Control (40)</th>
<th>Total (120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.72(8.80)</td>
<td>37.08(8.83)</td>
<td>37.10(8.83)</td>
<td>37.30(8.82)</td>
</tr>
<tr>
<td>38.78(9.82)</td>
<td>37.16(8.83)</td>
<td>37.16(8.83)</td>
<td>37.70(9.16)</td>
</tr>
<tr>
<td>39.01(8.90)</td>
<td>37.13(8.82)</td>
<td>37.13(8.82)</td>
<td>37.72(8.85)</td>
</tr>
</tbody>
</table>

Note: GIC= Glass Ionomer Cement
RMGIC= Resin Modified Glass Ionomer Cement  
(40)= n  
37.72= mean,  
(8,80)= standard deviation.

**Table 5. P-value of fluoroapatite in dentino-enamel substance**

<table>
<thead>
<tr>
<th></th>
<th>CvsGIC</th>
<th>CvsRMGIC</th>
<th>GICvsRMGIC</th>
<th>CvsGICvsRMGIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.983</td>
</tr>
<tr>
<td>3 days</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.825</td>
</tr>
<tr>
<td>10 days</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.850</td>
</tr>
<tr>
<td>20 days</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.821</td>
</tr>
</tbody>
</table>

note: C= control, GIC= glass ionomer cement, RMGIC= resin modified glass ionomer.  
P value ≤ 0.05

Fluoride ions released by the GIC and the RMGIC into the dentino-enamel substance will assist to alter hydroxyapatite crystal into fluoroapatite crystal, a more resistant compound to caries attack. In this study the P value of fluoroapatite between the control, GIC and RMGIC groups on observation made on day 1, 3, 10 and 20, showed no significant difference.

![Figure 4. Boxplot Table of Fluoroapatite Value in Dentino-enamel Substance](image-url)
In the boxplot table, an overlapping image may be observed if a straight line is drawn. This demonstrated that there were no significant differences in the amount of fluoroapatite crystal in the dentino-enamel substance between the control, GIC and RMGIC groups.

![Means Plots](image)

**Figure 5. Graphic of The Mean Value of Fluoroapatite in Dentino-enamel Substance**

**Discussion**

The development of minimal intervention principles in restorative treatment, increased application of GIC and RMGIC as restorative materials in dentistry. The superiority of these materials lies on its adhesive, biocompatibility and fluoride-ion releasing properties. Fluoride is considered to be a component which is necessary needed to prevent the development of dental caries. Fluoride content of GIC and RMGIC may be used in tooth caries prevention, since the released of fluoride ion may initiate its activity with saliva, and also the hard substances of the tooth to form a fluoroapatite compound which is beneficial to prevention of caries development or recurrence. An in vitro study was conducted to observe the effects of fluoride released by the GIC and RMGIC restorative materials to the salivary content and enamel as well as dentin to provide evidence whether the released of fluoride ions from these two restorative materials had any effects on the formation of fluoroapatite crystal in the dentino-enamel substance.

The premolar teeth extracted for orthodontic purposes, were used in this study so that there would be a similarity of the age of teeth used as study samples. The density of mineralized structure of enamel and dentin was influenced by the age of the tooth, where the older the age of tooth, the more dense the mineral content. The selection of caries free
and intact premolar teeth as samples in this study was meant to maintain the use of sound teeth that exhibit no damage in the hard substances. The soaking of teeth in saline solution was performed to keep the teeth moist since the presence of water is a prerequisite for the ion transportation.

The use of artificial saliva with no fluoride content may avoid the presence of fluoride ion in natural saliva, which may act as a confounding factor, so that the fluoride amount obtained in this study was the pure amount of fluoride ion derived from GIC or RMGIC fluoride release. Complete coverage of tooth surface by using nail polish or varnish may avoid a biased result, since fluoride ion from the saliva may penetrate the tooth hard substance. Thus, the alteration of apatite crystal is due to interactions between GIC or RMGIC and hard substance of tooth.

Moist is the requisite environment for the ion changing activity. In this in vitro study, an artificial saliva was used to create this sort of environment, but still, the teeth used as samples in this study were extracted teeth, which no water content in it, whereas water is the most important medium for ion changing process. The selection of each soaking time was based on the guidelines utilized in previous study which indicated that the highest amount of fluoride release encountered on day 1, remained stable until day 3, and gradually decreased until day 10, dan reached its lowest amount on day 20, which seemed stable afterwards. The artificial saliva had been constantly replaced every 24 hours, this was meant to resemble the natural condition of the mouth in which saliva was constantly flowing. Artificial saliva utilized in this study had no fluoride content, this was done in detecting the pure amount of fluoride released by GIC or RMGIC.

The analysis of fluoride content in saliva of the control group showed that fluoride was detected after one day of soaking; however, on day 3, 10 and 20, fluoride ion was not found. This demonstrated that the enamel and dentin of the tooth specimens already contained fluoride. Whereas in GIC and RMGIC groups, the amount of fluoride detected in the saliva was at its peak after one day of soaking, and gradually decreased until it became eventually stable on day 20. The fluoride ion released by GIC group was significantly higher than that of RMGIC group (Table 1), with different level and time variable in each group (Table 2, 3). When the three groups were compared to one another, significantly difference results observed in all periods of soaking. The analysis of fluoroapatite crystals formation in the three groups showed no significant difference related to different periods of soaking, this may be explained by the absence of differences both in the control or experimental groups, therefore the detected fluoroapatite crystals were the pre-existing structure before any experiments were applied to the specimens. This is in accordance with the result obtained from the saliva, where on day 1, tooth specimens in the control group released fluoride ion. Since there has been no fluoroapatite crystal formation observed from the dentino-enamel substance with the GIC or RMGIC restoration in it, thus the contained fluoroapatite crystal remained the same.

In other words, the fluoroapatite formation in the dentino-enamel substance required more that 20 days to occur, biological environment as well as sufficient water content. The hypothesis, stating that GIC groups formed greater amount of fluoroapatite, was denied.
Conclusion

GIC release higher fluoride in one day compared to RMCIC and control, meanwhile after 20 day, fluoride released from GIC and RMGIC are decreasing and has equal amount. Statistically, there was a significant difference of fluoride content in saliva among the three groups (GIC, RMGIC and control) in this study. No significant difference was found related to fluoroapatite crystal content in the dentino-enamel substance.

References


