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

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Abstract

Glass Ionomer Cement (GIC) and Resin Modified Glass Ionomer Cement (RMGIC) are two restorative materials in dentistry that have the capacity of releasing fluoride to saliva, dentino-enamel substance, and the ability to form fluoroapatite crystal. The aim of this study is to compare the amount of fluoride release in saliva and dentino-enamel substance. 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 ^{0}Celcius). Each group was divided again into 4 sub groups, each consisting 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 fluoroapatite 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 significance was set at $p \leq 0{,}05$. There was a 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. The fluoride content in saliva showed a significant difference within the 3 groups of GIC, RMGIC, and control. No significant difference was found in the fluoroapatite content on dentino-enamel substance.

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

Introduction

Glass Ionomer Cement (GIC) is an adhesive esthetic restorative material, found by Wilson and Kent in 1971, which consists of fluoride-rich *calcium fluoroalumino-silicate glass* powder, and *polyalcenoic 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 manufacturers 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 photo-sensitive 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. [1,2,5,6,12,13] 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 interrupt plaque accumulation on the surface of the restoration. [14,15] (Figure 1) Long-term release of fluoride ion from GIC and RMGIC has always been considered as one of its advantages, in which the peak of its fluoride release occurs at initial setting and decreases rapidly within the first 1 to 2 months to finally arrive at its stable rate, showing low amount yet constant release of fluoride. This was 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 (Figure 2), whereas in RMGIC, there

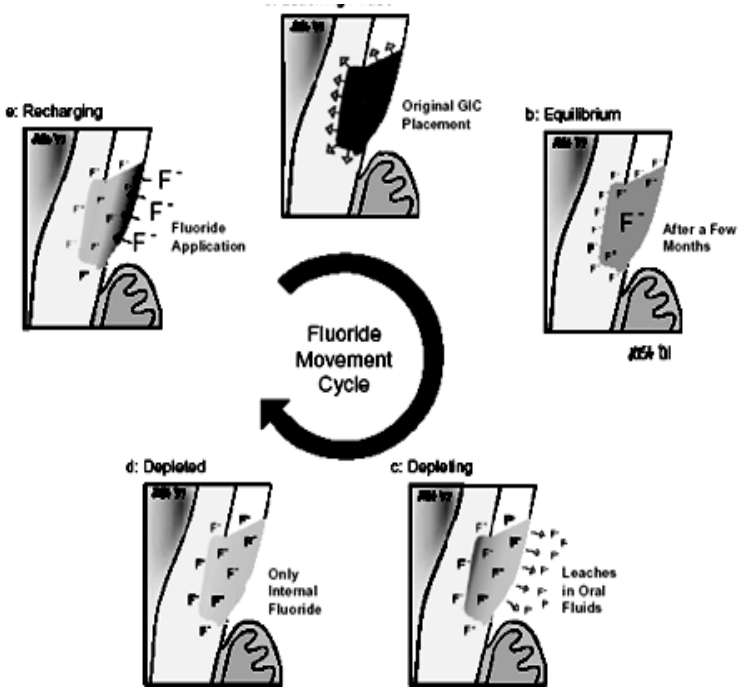

Figure 1. Fluoride movement cycle [14,15]

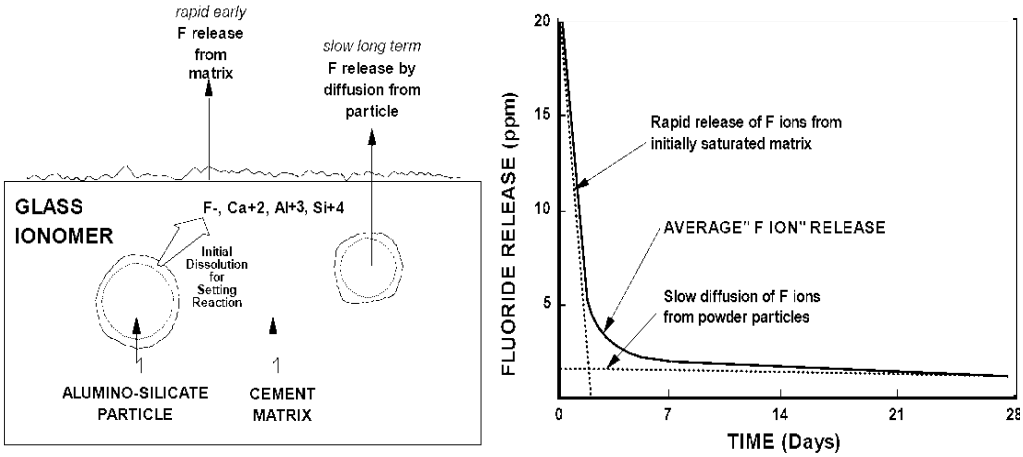

Figure 2. Fluoride Release from Glass Ionomer Cement [17]

was less amount of fluoride release, even though at the end of the study, both of those restorative materials showed the same amount of fluoride release in time. [5,6] Other authors stated that fluoride release from GIC may last up to 5 years. In addition, there are other authors who found out that fluoride release from the RMGIC occured only for 800 days.[9,10] In a study that compared the amount of fluoride release from the GIC and RMGIC in saliva, it was demonstrated that GIC released higher amount of fluoride compared to RMGIC.[11]

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 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.

Methods

Premolars teeth that are free from caries and other hard surface deformities which have been extracted for

orthodontic purposes were used in this research. The teeth were cleaned and soaked in saline solution to preserve their 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 which were completely covered with nail polish 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 with GIC (Fuji IX,GC Japan), the ones in the third group were filled with RMGIC (Fuji LC, GC Japan). These teeth were then soaked in artificial saliva without fluoride content and were incubated at room temperature (37 ^{0}C). Each group was further divided into 4 subgroups, each consisting 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 but analyzed using X-Ray Diffraction or XRD. Data obtained from the experiments were analyzed using ANOVA, and the level of significance was set at $p \leq 0,05$.

Results and Discussion

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 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. The value of fluoride content in the artificial saliva showed significant differences in all groups of different soaking periods.

By viewing the boxplot illustrated in Table 3, it is obvious that the highest amount of fluoride release occurs on the first day of the GIC group, followed by the first day of the RMGIC groups. It also showed that there were differences in significance rate due to the absence of overlapping illustration.

Table 1. Description of Fluoride Value in Artificial Saliva (ppm)

	GIC	RMGIC	Control	Total
	(40)	(40)	(40)	(120)
1 day	9.18(2.62)	2.01(0.81)	0.07(0.08)	3.75(4.26)
3 days	0.52(0.20)	0.22(0.14)	0.00(0.00)	0.25(0.26)
10 days	0.33(0.13)	0.07(0.03)	0.00(0.00)	0.13(0.16)
20 days	0.05(0.02)	0.05(0.03)	0.00(0.00)	0.04(0.03)

Note: GIC =Glass Ionomer Cement
RMGIC = Resin Modified Glass Ionomer Cement
(40) = n, 9; 18 = mean, (2.62) = standard deviation

Table 2. P-value of Fluoride in Artificial Saliva

	p-value					
	1dvs3d	1dvs10d	1dvs20d	3dvs10d	3dvs20d	10dvs20d
Control	1.000	1.000	1.000	1.000	1.000	1.000
GIC	0.000*	0.000*	0.000*	1.000	0.982	1.000
RMGIC	0.001*	0.000*	0.000*	1.000	1.000	1.000

Note: d=day,
GIC=glass ionomer cement,
RMGIC=resin modified glass ionomer cement
P value $\leq$ 0,05
*significant

Table 3. Comparison of P-Value of Fluoride in Artificial Saliva

	P value
	Control Vs GIC Vs RMGIC
1 day	0.000*
3 days	0.000*
10 days	0.000*
20 days	0.000*

Note: GIC = Glass Ionomer Cement,
RMGIC = Resin Modified Glass Ionomer Cement
p $\leq$ 0,05
*significant

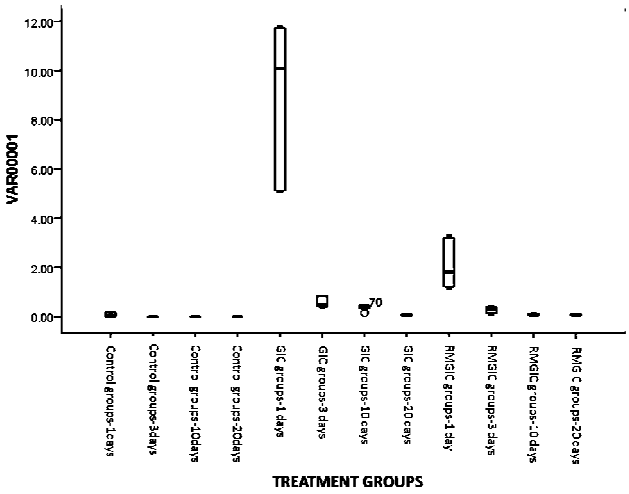

Figure 3. Boxplot Table Showing the Value of Fluoride in Artificial Saliva of the Three Groups According to Different Soaking Periods

The fluoroapatite in dentino-enamel substance. 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 differences.

Table 4: Description of the Value of Fluoroapatite in Dentino-Enamel Substance (ppm)

	GIC (40)	RMGIC (40)	Control (40)	Total (120)
1 day	37.72(8.80)	37.08(8.83)	37.10(8.83)	37.30(8.82)
3 days	38.78(9.82)	37.16(8.83)	37.16(8.83)	37.70(9.16)
10 days	39.01(8.90)	37.13(8.82)	37.13(8.82)	37.72(8.85)
20 days	39.36(8.84)	39.38(9.30)	39.38(9.30)	39.37(9.15)

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

	CvsGIC	CvsRMGIC	GICvsRMGIC	CvsGICvsRMGIC
1 day	1.000	1.000	1.000	0.983
3 days	1.000	1.000	1.000	0.825
10 days	1.000	1.000	1.000	0.850
20 days	1.000	1.000	1.000	0.821

Note: C = control
GIC = glass ionomer cement
RMGIC = resin modified glass ionomer
P value ≤ 0.05

The development of minimal intervention principles in restorative treatment increases application of GIC and RMGIC as restorative materials in dentistry. The superiority of these materials lies on their adhesive, biocompatibility, and fluoride-ion releasing properties. Fluoride is considered to be a component which is necessarily needed to prevent the development of dental caries. Fluoride content of GIC and RMGIC may be used in tooth caries prevention since the release of fluoride ion may initiate its activity with saliva, and also the hard substances of the teeth to form a fluoroapatite compound which is beneficial for the 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 release 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 teeth, where the older the age of teeth, the denser the mineral content will be. 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 prevent 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 prevent 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 teeth.

Moisture 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, in which there is no water content, 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.[7,8,9] The artificial saliva had been constantly replaced every 24 hours, and this was meant to resemble the natural condition of the mouth in which saliva was

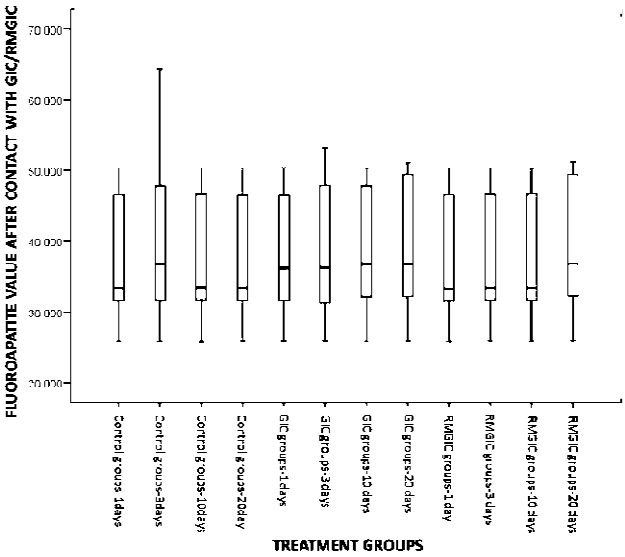

Figure 4. Boxplot Tabel of Fluoroapatite Value in Dentino-enamel Substance

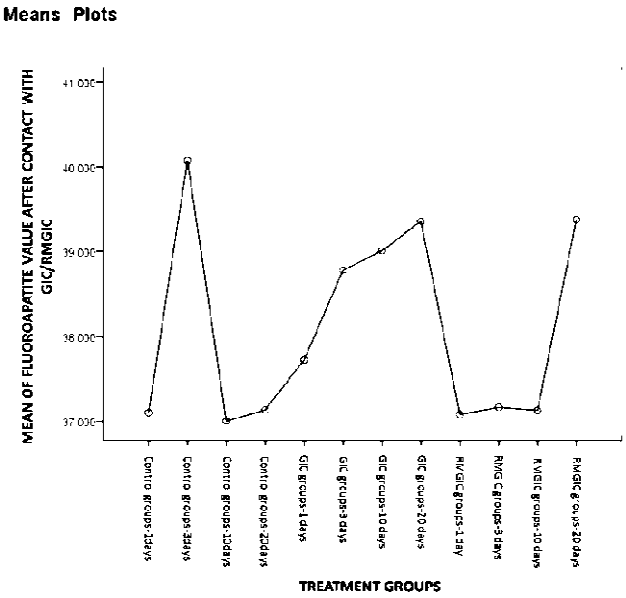

Figure 5. Graphic of the Mean Value of Fluoroapatite in Dentino-enamel Substance

constantly flowing. Artificial saliva utilized in this study had no fluoride content, and this was done in detecting the pure amount of fluoride released by GIC or RMGIC.

The analysis of flouride content in saliva of the control group showed that fluoride was detected after one day of soaking; however, on day 3, 10, and 20 days, fluoride ion was not found. This demonstrated that the enamel and dentin of the tooth specimens already contained fluoride. On the other hand, 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 different results were observed in all periods of soaking.

The analysis of fluoroapatite crystals formation in the three groups showed no significant differences 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 and biological environment as well as sufficient water content may require more that 20 days to occur. The hypothesis, stating that GIC groups formed greater amount of fluoroapatite, was denied.

Conclusion

GIC releases higher fluoride in one day compared to RMCIC and control, meanwhile after 20 days, flouride released from GIC and RMGIC decreases 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.

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