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Comparative Evaluation of the Effect of Various Surface Coating Agents on Fluoride Release from Conventional Glass Ionomer Cement in Deionized Water, Artificial Saliva and Lactic Acid - An *In-Vitro* Study

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ABSTRACT

Introduction: To know the effect of surface coating agents on the fluoride release property of conventional Glass Ionomer Cements (GIC) when stored in different storage media.
Materials and Method: Forty-five pellets were fabricated from conventional GIC (GC Fuji type ii capsules) and were randomized into three groups (Group I, II and III)of 15 each. Group I samples were uncoated, group II coated with petroleum jelly and group III were coated with G-coat plus (Nano-filled protective coating). Each group were divided into 3 subgroups consisting of 5 samples which were suspended in each immersion solution in deionized water, artificial saliva and lactic acid and were renewed every 24 hours for 15 days. The fluoride release was measured on day 1st,3rd, 7thand 15thby using UV light visible spectrophotometer.
Results: In deionized water and artificial saliva, for all the 3 groups the mean fluoride release values were found to be fluctuating, as, from 1st day it showed a increased release on 3rd day and subsequently decreased till 15th day where as in lactic acid, it showed a highest release on 1st day and then gradually decreased till 15th day. On intergroup comparison, G-coat plus showed very minimal fluctuation of fluoride release and was statistically significant.
Conclusion: The result concludes that fluoride release from the conventional GIC was reduced with the application of surface coating and maximum fluoride release was observed in low pH environment. Conventional GIC when protected with G-coat plus showed minimal fluctuation in fluoride release, thus allowing sustained release for a longer period of time.

Keywords: Fluoride Release, Surface Coating Agents, Glass Ionomer Cement, Deionized Water, Artificial Saliva and Lactic Acid

INTRODUCTION

Dental caries is a multifactorial disease in which fermentation of dietary sugars by bacteria from the oral biofilm leads to localized demineralization of tooth surfaces, which may ultimately result in cavity formation[1]. The GICs are one of the products developed in this direction and are widely used in Paediatric operative dentistry because of their ability to adhere to/bond with enamel and dentin without any pre-treatment and potential to release fluoride ions over a prolonged period of time[2]. Although in addition to their advantages, GIC possesses undesirable characteristics and some limitations like loss of microhardness and luminousness due to early moisture sensitivity before setting and desiccation in dry condition, poor wear resistance, low strength and average esthetics[2]. To overcome the drawback of moisture sensitivity, the application of different coatings like water proof varnish, petroleum jelly, cocoa butter, or chemical/light cured bonding resins over the surface of the material immediately following the initial set to maintain the water balance during maturation have been suggested and are embedded into practice[2].

Most of the studies have been performed to study the pattern of fluoride release from various restorative materials in neutral pH or inert solutions like deionized or double distilled water. Very few studies have been conducted on fluoride release pattern during the caries experience which actually occurs in the mouth[3].

However, there is very limited existing literature on the influence of fluoride release of these protective coatings in a solution which simulate oral environment and also necessary to compare between different surface protective agents over conventional GICs. Therefore, the aim of the study was to evaluate and compare the effect of various surface coating agents on fluoride release from Conventional Glass Ionomer Cement in deionized water, artificial saliva and lactic acid.

MATERIALS AND METHODS

For the present study, a total of forty five pellets of Conventional Glass Ionomer Cement-GC Fuji type II capsules were made by using brass moulds (6.5 mm in diameter x 2 mm in thickness).The pellets were fabricated by mixing the cement according to the manufacturer's instructions. The material was immediately covered with mylar strip and supported by glass slabs on either side, held under hand pressure and compressed to extrude excess material. After setting, any excess material around the periphery was removed with a scalpel and the pellets were gently demoulded. Samples with voids and uneven surface texture were excluded from the study. Samples were randomized into three groups (Group I,II and III)of 15 each. Group I samples were uncoated, group II coated with petroleum jelly and group III were coated with G-coat plus (Nano-filled protective coating) and the surface protective agents were uniformly applied accordingly to the manufacturer's instructions. Each group were divided into 3 subgroups consisting of 5 samples which were suspended in each immersion solutions, Deionized water (pH -7.0) Subgroup I,II,III (a), Artificial saliva (pH - 6.9) Subgroup I,II,III (b)and lactic acid(pH - 5.2) Subgroup I,II,III (c) and were renewed every 24 hours for 15 days.

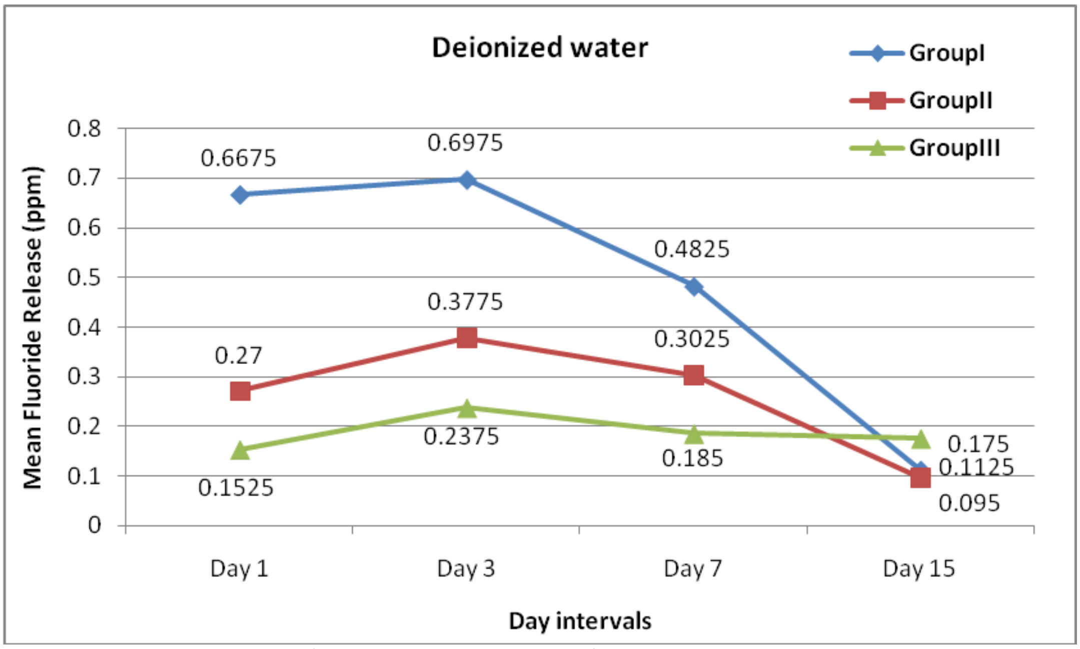
Each sample was suspended individually in 100 ml of their respective medium, stored in polypropylene containers shown in Figure.1and were placed in incubator at constant temperature of 37°C for 24 hours. At the end of the 24 hours, the samples were taken out of the containers and they were dried with absorbent paper and transferred immediately to another 100 ml of the fresh medium. The solutions were renewed every 24 hours for 15 days and collected, labelled and stored. The fluoride release was measured on 1st, 3rd, 7th and 15thday. Estimation of fluoride ion release was measured by using UV light visible spectrophotometer at 570 nm wavelength.

RESULTS

The data concerning fluoride ion release were recorded in parts per million (ppm) and the data were tabulated respectively. The tabulated data were statistically analysed by using SPSS software 14 version. One way ANOVA and Post-hoc Tukey's test using Duncan method were applied to compare the mean difference in fluoride release values (ppm) among all the three groups.

In the present study, for the Uncoated in deionized water (Subgroup I a), the mean fluoride release values (Graph-1) were found to be fluctuating. It showed a highest release on 3rd day and subsequently declined till 15th day. For Petroleum jelly in deionized water, showed a highest release on 3rd day and subsequently decreased till 15thday. For G-coat plus in deionized water, showed very minimal fluctuation with the highest release on 3rd day and subsequent decline till 15th day.

In deionized water intergroup comparison (Table-1) were done among all the three groups. On comparison, the interpreted values of day 1,Uncoated with Petroleum jelly & Uncoated with G-coat plus and values of day 7, Uncoated with G-coat plus & Petroleum jelly with G-coat plus and values of day 15, Uncoated with G-coat plus & Petroleum jelly with G-coat plus were statistically significant ($p<0.001$).



Graph :1The mean fluoride release values (ppm) of all the three groups in deionized water

Group I: Uncoated
Group II : Petroleum Jelly
Group III :G-coat plus

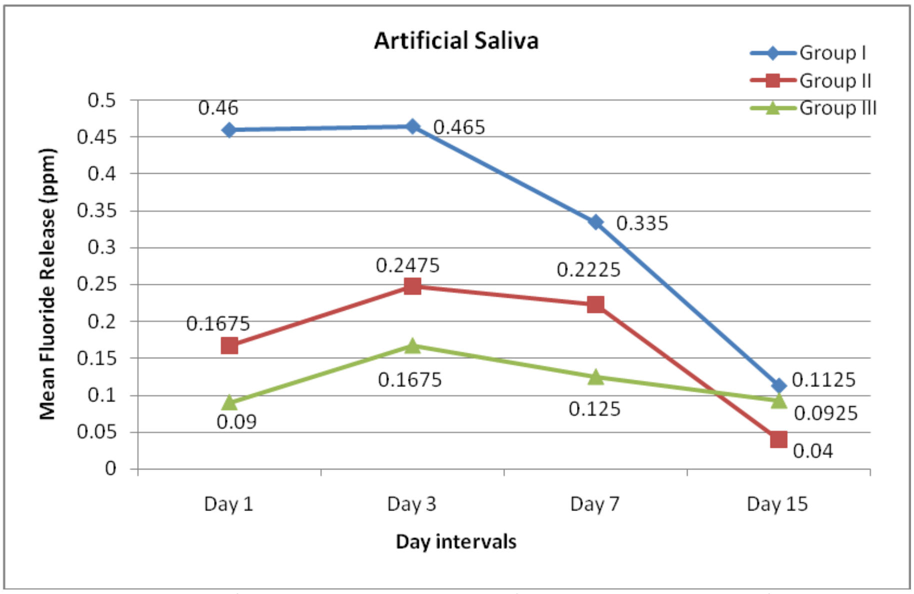
Table- 1 Intergroup comparison of the mean difference in fluoride release values (ppm) among all the three groups in deionized water on different day intervals

Group	Day 1			Day 3			Day 7			Day 15		
	Mean	Mean difference	p-value	Mean	Mean difference	p-value	Mean	Mean difference	p-value	Mean	Mean difference	p-value
Uncoated	0.6675	0.507	0.001 (S)	0.6975	0.345	0.43 (NS)	0.4825	0.180	0.001 (S)	0.1125	0.175	0.10 (NS)
Petroleum Jelly	0.2700			0.3775			0.3025			0.0950		
Uncoated	0.6675	0.405	0.001 (S)	0.6975	0.435	0.28 (NS)	0.4825	0.297	0.001 (S)	0.1125	0.650	0.001 (S)
G-coat plus	0.1525			0.2375			0.1850			0.1750		
Petroleum Jelly	0.2700	0.102	0.20 (NS)	0.3775	0.009	0.94 (NS)	0.3025	0.117	0.001 (S)	0.0950	0.825	0.001 (S)
G-coat plus	0.1525			0.2375			0.1850			0.1750		

S- Significant
NS- Not Significant

In the present study, for the Uncoated, in artificial saliva (Subgroup I b), the mean fluoride release values (Graph-2) were found to be fluctuating showed a highest release on 3rd day and were then declined till 15thday. For Petroleum jelly, in artificial saliva, fluctuatingshowed a highest release on 3rd day and subsequently decreased till 15th day. For G-coat plus in artificial saliva, showed very minimal fluctuations with the highest release on 3rd day and subsequent decline till 15th day.

In artificial saliva groups intergroup comparison (Table-2) were done among all the three groups. On comparison, the interpreted values of day 7, Uncoated with Petroleum jelly& Uncoated with G-coat plus & Petroleum jelly with G-coat plus and values of day 15, Uncoated with Petroleum jelly & Uncoated with G-coat plus & Petroleum jelly with G-coat plus were statistically significant ($p<0.001$).



Graph: 2 The mean fluoride release values (ppm) of all the three groups in artificial saliva

Group I : Uncoated
Group II : Petroleum Jelly
Group III :G-coat plus

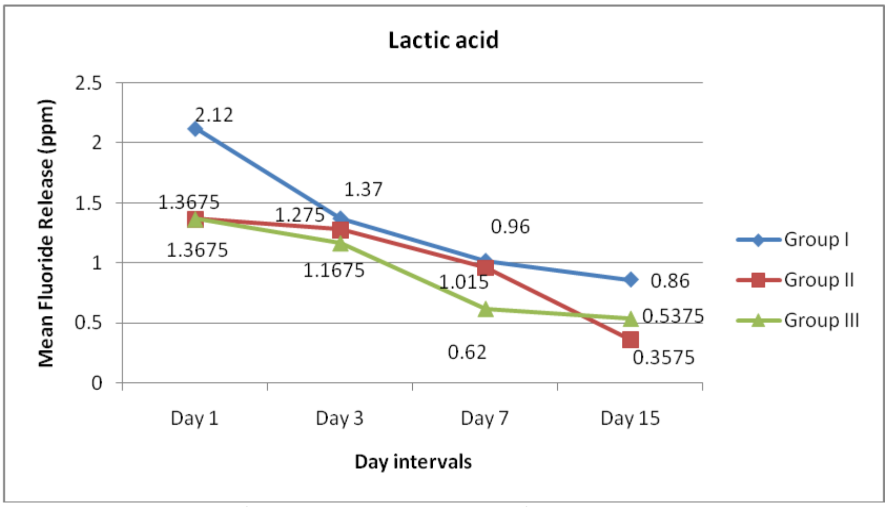
Table-2 Intergroup Comparison of the mean difference in fluoride release values (ppm) among all the three groups in artificial saliva on different day intervals

Group	Day 1			Day 3			Day 7			Day 15		
	Mean	Mean difference	p-value	Mean	Mean difference	p-value	Mean	Mean difference	p-value	Mean	Mean difference	p-value
Uncoated	0.4600	0.215	0.50 (NS)	0.4650	0.272	0.40 (NS)	0.3350	0.137	0.001 (S)	0.1125	0.0850	0.001 (S)
Petroleum Jelly	0.1675			0.2475			0.2225			0.0400		
Uncoated	0.4600	0.215	0.50 (NS)	0.4650	0.257	0.44 (NS)	0.3350	0.235	0.001 (S)	0.1125	0.0325	0.001 (S)
G-coat plus	0.0900			0.1675			0.1250			0.0925		
Petroleum Jelly	0.1675	0.001	1.00 (NS)	0.2475	0.015	0.99 (NS)	0.2225	0.097	0.001 (S)	0.0400	0.0525	0.001 (S)
G-coat plus	0.0900			0.1675			0.1250			0.0925		

S- Significant
NS- Not Significant

In the present study, for the Uncoated, in lactic acid (Subgroup I c), the mean fluoride release values (Graph -3) were found to be fluctuating showed a highest release on day 1 and subsequently decreased till day15. For the Petroleum jelly, in lactic acid were found to be fluctuating showed a highest release on 1st day and were then decreased to 15th day. For G-coat plus in lactic acid, showed very minimal fluctuations with the highest release on 1st day and subsequent decline till 15th day.

In lactic acid intergroup comparison (Table-3) were done among all the three groups and On comparison, the interpreted values of day 1,Uncoated with Petroleum jelly & Uncoated with G-coat plus and values of day 3,Uncoated with G-coat plus and values of day7,Uncoated with G-coat plus & Uncoated with Petroleum jelly & Petroleum jelly with G-coat plus and values of day 15,Uncoated with G-coat plus &Uncoated with Petroleum jelly & Petroleum jelly with G-coat plus were statistically significant (p<0.001).



Graph:3. The mean fluoride release values (ppm) of all the three groups in lactic acid

Group I: Uncoated
Group II : Petroleum Jelly
Group III : G-coat plus

Table-3 Intergroup comparison of the mean difference in fluoride release values (ppm) among all the three groups in lactic acid on different day intervals

Medium	Day 1			Day 3			Day 7			Day 15		
	Mean	Mean difference	p-value	Mean	Mean difference	p-value	Mean	Mean difference	p-value	Mean	Mean difference	p-value
Uncoated	2.1200	0.753	0.01 (S)	1.3700	0.0950	0.49 (NS)	1.0150	0.0550	0.001 (S)	0.8600	0.507	0.001 (S)
Petroleum Jelly	1.3675			1.2750			0.9600			0.3575		
Uncoated	2.1200	0.753	0.01 (S)	1.3700	0.202	0.01 (S)	1.0150	0.395	0.001 (S)	0.8600	0.337	0.001 (S)
G-coat plus	1.3675			1.1675			0.6200			0.5375		
Petroleum Jelly	1.3675	0.001	1.00 (NS)	1.2750	0.107	0.41 (NS)	0.9600	0.340	0.001 (S)	0.3575	0.170	0.001 (S)
G-coat plus	1.3675			1.1675			0.6200			0.5375		

Figure 1:

DISCUSSION

GICs has the unique property of being cariostatic due to the sustained release of fluoride[4]. The use of GICs has the ability to provide a reservoir of fluoride for remineralization and create a caries inhibitory zone at the interface between the cement and tooth surface[5].The clinical importance of fluoride release rests on its anticariogenic property and there were many studies concerning fluoride release from GICs[6].

The initial high amounts of fluoride rapidly decrease after 24-72 hours, and plateau to a nearly constant level within 10-20 days[7]. This release occurs through two processes from dental restorative materials: a faster superficial erosion, i.e., dissolution of the material, releasing all its component parts, including fluoride, and a continuous diffusion, which can be either the release of fluoride in conjunction with an appropriate counter ion, typically sodium, or fluoride release via exchange with hydroxyl

.Fluoride release is an important property of Glass Ionomers. Studies have shown that varnishes reduce fluoride release by between 61% and 76%, depending on the cement and the varnish[8].

Search in this field led to the use of nanofillers in surface coating agents to improve its wear resistance, but their effect on fluoride release is not clear and the influence of fluoride release of these protective coatings in a solution which simulate oral environment and also necessary to compare between different surface protective agents over conventional GICs. Thus, in the present in-vitro study, the surface protective coating agents namely, G-coat plus and Petroleum jelly were used.

The fluoride elution is not a straight forward process and can be governed by various intrinsic and extrinsic factors. The intrinsic factors are composition, powder/ liquid ratio, mixing time, temperature, specimen geometry, permeability, surface treatment and finishing. The extrinsic factors include type of storage medium, experimental design (volume of storage medium, frequency of medium change, stirring) and analytical methods[9].

In the present study, brass moulds were made with a specification of which ensured the standardization of shape and size of each pellet of restorative material[10]. Deionized water was chosen for the experiment as it provided the baseline of fluoride release potential in unstipulated conditions and also gives an accurate estimation of the fluoride ions released, since there are no existing ions in the medium[3,11]. Artificial saliva was chosen as a second medium for fluoride leaching so as to simulates to an extent the natural oral environmental conditions, although, duplicating exactly the properties of human saliva is impossible due to the inconsistent and unstable nature of natural saliva.[3]The third medium chosen was the lactic acid, stating that in addition to acetic acid, lactic acid accounts for about 70 percentage of the total acids present in the dental plaque of the subject examined, after sucrose rinsing and was due to rapid sucrose degradation by lactate-producing bacteria such as *Streptococcus mutans*[12].

In the present study, both in Deionized water and Artificial saliva the highest fluoride release was observed on third day, which is in agreement with the earlier studies as reported that, the conventional GIC showed the highest fluoride release on the first three days.[13] The initial high burst of fluoride release was due to the high concentration of fluoride ions that exists in matrix after setting reaction was complete[14].

However in the present study, it was observed that the fluoride release values were found to be lower in artificial saliva than in deionized water and were consistently different which is in agreement with the earlier studies, may be due to the presence of cations and anions and its ionic effect on the solubility of the material. Also, it may be due to the formation of CaF_2, which precipitated on the surface of the material and formed an insoluble layer, resulting in a physical barrier and thus reduction of fluoride release[3,15]. The level of fluoride release in the present study was highest in lactic acid compared to deionized water and artificial saliva. These findings were in accordance with the study reported byAnupamaKiran *et al.,*[16]and it was explained that the amount of fluoride release was increased under acidic conditions, as it is also dependent on the acidic nature[6].

The results of the intergroup comparison of fluoride release among all the 3 groups, Uncoated showed a highest fluoride release compared with Petroleum jelly and G-coat plus. This was in agreement with the findings of Tiwari S and Nandlal B[17] who stated that, the uncoated released significantly more fluoride than surface coated. The possible explanation for that would be without protection immature glass ionomer was quite soluble in water and application of surface coating agent led to the reduction in the release rates of fluoride from conventional GICs. Surface protection of GICs definitely impedes the fluoride release property which might be due to the associated reduction in the movement of water[2].

The fluoride release values were found to be lower in Petroleum jelly compared to Uncoated in deionized water, artificial saliva and lactic acid. This was in accordance with Rekhalakshmi K and Sharada Reddy J[2] who stated that, petroleum jelly impedes the fluoride release, but to a very less extent. The mean fluoride release values of G-coat plus in deionized water, artificial saliva and lactic acid it was observed that, the fluctuations were found to be very minimal. This was in agreement with the findings of Tiwari S and Nandlal B[17]. The results suggesting that, G-coat plus varnish which incorporates dispersion nano-filler technology, allows a uniform dispersion of nano sized fillers enhances the wear resistance and provides protection against acid attack. Thus, when applied on conventional glass ionomer restoration it reduced the burst effect of fluoride release during the 1st week and allowed for sustained and steady release of fluoride.

CONCLUSION

From the results of the present study, it could be concluded that, the fluoride release from the Conventional Glass Ionomer Cement was reduced with the application of surface protective coating agent and maximum fluoride ion release was observed in low pH environment. Conventional Glass Ionomer Cement when protected with G-coat plus a nano-filled self adhesive coating showed minimal fluctuation in fluoride release, thus allowing sustained release of fluoride for a longer period of time.

Limitation of the present study:

- In the present study, the fluoride release was evaluated for a period of 15 days and the results of this study have to be substantiated with further long-term studies with different day intervals.
- Further studies are needed to evaluate the fluoride releasing property in Demineralizing – Remineralizing regimens.
- The influence of the surface protective agents on fluoride rechargeability and re-release has to be assessed with the routine use of fluoridated dentifrices and solutions and also tooth brushing, dietary habits and oral hygiene maintenance.

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