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***Original article***

# Evaluation of fluoride release ability of three different types of GIC: An in vitro study

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ABSTRACT

Statement of problem: Secondary caries are the prime concern after the restoration and tooth receiving crown. As time progresses the chances of secondary caries increases if suitable restorative material is not used.

**Aim of the study** : This study evaluate the fluoride releasing ability of three different types of Glass Ionomer formulation including Glass Ionomer cement(GC-9, Gold lable), Glass Ionomer FX-II (shofu-Japan), Ketac Molar(3M).

**Methodology** : A total of 10 cylindrical specimen for each of 3 materials were prepared followed by manufacturer instructions & immersed independently in 25 ml of artificial saliva & stored as group-1 to 3. The Fluoride release was evaluated on $1^{st}$ , $7^{th}$ & $28^{th}$ day using fluoride ion specific electrode.

**Summary of Result** : Our study showed that all 3 types of glass-ionomer cements released fluoride. The most important fluoride release took place during the first 24 hours. It then gradually increased and became constant during the following days of the study. Our results in the first 24hrs demonstrated that the concentrations of fluorine ions released were insignificantly higher in all three groups. But release of fluoride is comparatively lower in FX-II than GC-9 and Ketac molar.There is considerable increase in fluoride release was seen in all three groups in at $7^{th}$ day. Though FX-II has maintained lower release compared to GC-9 and Ketac molar. Over all release of fluoride is diminished at the $28^{th}$ day

## Introduction

Fluoride gives hardness and durability to the tooth and protects it against caries. It has been successful to add fluoride to the tooth enamel in a soluble and absorbable form." Erhad`t 1874[1].

Low concentrations of fluoride have a beneficial effect on dental hard tissues and in the prevention of caries. However, after fluoride treatments, salivary fluoride concentrations decrease to very low concentrations within a few hours. Therefore, fluoride releasing dental materials can be alternative systems in order to maintain long-term fluoride release in the oral environment[2].

The anticariogenic effects of fluoride may be due to several mechanisms. Fluoride taken up by the tooth reduces demineralization and enhances remineralization. Fluoride ions also play a role in the interference of pellicle and plaque formation and the inhibition of microbial growth[3].

Many authors suggest that fluoride in low concentrations is necessary in oral fluids in order to decrease caries incidence.4-6 Caries incidence decrease is due to a reduction in enamel solubility to

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oral acids, as well as inhibition of bacterial enzymes elicited by the fluoride[7,8].

One of the common causes for the post-operative failure of restorations is secondary or recurrent caries[9].

It is a well-established fact that the incidence and severity of secondary caries are reduced around restorations that release fluoride. The leached fluoride acts as a topical application to increase the fluoride content of the surrounding tooth structure, thereby minimizing caries by forming fluorapatite crystals, which are more resistant to acid attack[10].

The ability of glass ionomer cements (GIC's) to release fluoride has been known for some 20 years and has been a significant factor in their increasing use in dentistry[11]

The fluoride release of glass ionomers depends on the type of glass ionomer, the initial fluoride content of the glass, mixing and setting times, and pH changes in the environment[12].

Studies have also shown that glass ionomers take up fluorides, which are lost from leaching in the oral environment and release it again in a dynamic process, thereby enabling the material to be looked upon as a "re-chargeable slow-release fluoride system." The presence of fluoride in the oral environment thus guarantees long-term fluoride release, from these restorations in the oral cavity the fluoride binds chemically to the glass ionomer and it gradually releases it, and a continuous release uptake process thereby occurs. Two big disadvantages of the conventional glass ionomer cement (GIC) are its opaqueness that gives it poor esthetics and poor edge strength. Hence, modifications of GICs are being introduced to overcome the deficiency. Some of the modifications are the resin-modified GICs, compomer, Type VII, IX GP[10].Certain intrinsic variables are involved in the fluoride release process. They are mainly determined by the way the cement is manufactured: the composition of the aluminum-silicate glass and polyalkenoic acid, the size of the powder particle, the relative proportion of components (glass/polyacid/tartaric acid/water) in the mixed cement, and finally, the mixing process[13]. When the components of the glass ionomer are mixed, they experience a reaction involving neutralization of acid groups elicited by the solid base of the glass powder. Important amounts of fluoride are released during the mixing process and after the reaction: this release is higher during the first days[14,15].

Studies have shown that GICs are the most effective fluorine-releasing materials. Considering the importance of fluoride release and the significant role it plays in caries resistance and reducing its progression, the following study was conducted to evaluate the fluoride release and uptake from different types of GIC.

## MATERIALS AND METHOD:

Ten specimens were made for each of the following three materials and were grouped as Group I- Glass ionomer cement (GC-9, Gold label), Group II: Ketac Molar (3M) and Group III: Glass Ionomer FX-II (shofu-Japan).

## PREPARATION OF SPECIMEN:

All materials were handled according to manufacturer instructions. After mixing, the materials were placed in a plastic mold of 10 mm diameter and 2 mm height. These specimens were covered with a plastic sheet on both sides and placed between two glass plates. The specimens were then transferred to plastic containers containing artificial saliva.


**PREPARATION OF ARTIFICIAL SALIVA:**

Artificial saliva was prepared by adding 0.111 g of calcium chloride, sodium dihydrogen phosphate 0.156 g, sodium chloride 2.05 g, sodium acetate 2.05 g to 1000 ml of de-ionized water. The pH was adjusted to seven by adding potassium hydroxide.

**FLUORIDE ION EVALUATION:**

Fluoride ion measurement was done using a combination of fluoride ion electrode (9609 BN Orion Research, Inc. Beverely , MAO 1915-6199) coupled to a microprocessor ion analyzer(EA 940 Orion Analyzer, Orion research).10 ml of saliva was mixed with 10% by volume of total ionic strength adjustment buffer(TISAB) to provide a constant background ionic strength and to de-complex the fluoride. The TISAB contains 2% cyclohexyline dinitrilotetracetic acid, a metal chelating agent that partially decomposes fluoride from polyvalent cations, therefore, making fluoride available for measurement. The fluoride measurement was evaluated on the 1$^{st}$,7$^{th}$ and 28$^{th}$ day.

**RESULTS:**

Mean and standard deviation of fluoride release were estimated from each group on day 1. Statistical analysis by one-way ANOVA showed that there is significant difference in mean values between groups I (5.53±0.31), II (5.58±0.35) and III (2.72±0.35) at day-l (*P* = 0.000) (Table 1). It is also evident that fluoride release was lower in group III compared to group I and II. At day 7 in groups I (12.54±0.31), II (16.80±0.47) and III (5.78±0.34) (Table 2), it was found that the mean values in all groups were significantly higher than on the 1$^{st}$ day. The statistical analysis with one-way ANOVA showed that there is significant difference in mean values between groups. The observations were also made at 28$^{th}$ day. Groups I (2.82±0.49), II (3.32±0.49) and III (1.58±0.29) (Table 3), showed significant lower values than on the 1$^{st}$ and 28$^{th}$ day.

**DISCUSSION:**

According to studies conducted by Dr Forsten, fluoride is the most effective caries-prevention agent. The metabolism of the caries-causing bacteria is inhibited and dentin and enamel resistance are increased. Porous enamel and softened dentin can be

**TABLE 1:**

| | Mean | Standard deviation | F value | P value |
|---|---|---|---|---|
| Group I | **5.53** | **0.31** | **229.68** | **0.000** |
| Group II | **5.58** | **0.35** | | |
| Group III | **2.72** | **0.35** | | |

**Table 2:**

| | Mean | Standard deviation | F value | P value |
|---|---|---|---|---|
| Group I | **12.54** | **0.31** | **2068.56** | **0.000** |
| Group II | **16.80** | **0.47** | | |
| Group III | **5.78** | **0.34** | | |

remineralized when subjected to the presence of fluoride.[16] Fluoride contributes to caries inhibition in the oral environment by means of both physicochemical and biological mechanisms. Inhibit the enzymatic production of glucosyl transferase, which prevents the glucose from forming extracellular polysaccharides and reduces bacterial adhesion and slows down the ecological succession. The intracellular polysaccharide formation is also inhibited, thus preventing the storage of carbohydrates by limiting the microbial metabolism between the host meals.[10]

Fluoride inhibits the demineralization through the formation of fluorapatite and enhances the remineralization of carious, non-cavitated enamel and biologic mechanisms include inhibition of carbohydrate metabolism by acidogenic plaque microflora. The fluoride enters the microorganisms against a concentration gradient and accumulates intracellularly. The extra cellular pH decreases the

**TABLE 3:**

| | Mean | Standard deviation | F value | P value |
|---|---|---|---|---|
| Group I | **2.82** | **0.49** | **40.90** | **0.000** |
| Group II | **3.32** | **0.49** | | |
| Group III | **1.58** | **0.29** | | |

transport of hydrogen fluoride into cells leads to dissociation of hydrogen fluoride into $H^+$ and $F^-$ in the alkaline cytoplasm. Thus, the ionic fluoride inhibits the acid production.[17]Several investigations have been performed on $F^-$ release from dental materials, as this property is related to their cariostatic effect. The release of $F^-$ from dental materials is governed by various intrinsic and extrinsic factors. The intrinsic factors include composition, powder/liquid ratio, mixing time, temperature, specimen geometry, permeability, surface treatment and finishing. Temperature, specimen geometry, permeability, surface treatment and finishing were standardized for all materials. However, the composition, powder/liquid ratio and mixing time vary in according to the studied materials. Extrinsic factors include type of storage medium, experimental design and analytical methods. These extrinsic factors make difficulty any comparison between our data and those from other studies.[18]

The fluoride-releasing ability of GICs has been shown to offer resistance to secondary caries formation around restorations27 as a result of fluoride penetration into mineralized dentin.[19]

All restorative materials showed more release after 24 h, this was decreased on 7th day and 15th day. The fluoride release after 24 h was maximum because of surface wash off effect. Fluoride release from glass ionomer cement is diffusion limited and affected by concentration in both the cement matrix and the particles. During the initial acid dissolution of powder particle surfaces, a large amount of fluoride becomes part of reaction product matrix. This fluoride diffuse quickly from the matrix exposed on the surface of the material and is slowly replaced by fluoride diffusing from the matrix below the surface. This is responsible for the phenomenon of "burst effect", wherein high amount of fluoride are released after 24 h.[12]

Fluoride release declines rapidly after 7th day then decreases gradually on 15th day. The probable explanation for this rapid decrease is release of fluoride occurs also by diffusion through pores and cracks. It is smaller but at a more constant level. This is presented by a long period of fluoride release at a nearly constant level 7-15 d after preparation of samples.[20]

The fluoride released by the GICs was found to be highest during the first 24 h and decreased significantly over the 1st week with lower levels obtained on the 7th and 28th day.[10]

It was established that the amount of released fluoride from GIC was greater during the fi rst 24 hours (burst effect), to then decline on the second day, and then gradually decrease with the passing of time.[13]

The highest F- release from the restorative materials studied was observed at the first day and decreased thereafter up to the third day. The high level of F- release on the first day might have been caused by the initial surface loss; while the relatively constant F- release during the following days might be due to the F- ability to diffuse through cement pores and fractures.[18]

Our results in the first 24hrs demonstrated that the concentrations of fluorine ions released were insignificantly higher in all three groups. But release of fluoride is comparatively lower in FX-II than GC-9 and Ketac molar.

There is considerable increase in fluoride release was seen in all three groups in at 7$^{th}$ day. Though FX-II has maintained lower release compared to GC-9 and Ketac molar. Over all release of fluoride is diminished at the 28$^{th}$ day.

The results of this study are compatible to other studies demonstrating the mode of fluorine release by GICs, characterized at first by an initial rapid release.

*In vitro* results may not be directly representative of *in vivo* results. Fluoride release was measured from specimens immersed in a static medium, and that may not take into account the dynamic nature of conditions in the oral cavity.

**CONCLUSION:**

OUR STUDIES showed that all 3 types of glass-ionomer cements released fl uoride. The most important fluoride release took place during the first 24 hours. It then gradually increased and became constant during the following days of the study.

Carious tooth destruction results from episodes of demineralization of tooth structure exceeding remineralization over time. Consequently, to optimize the possibility for recurrent caries inhibition, a sustained level of fluoride release over time from a restorative material-adhesive system is necessary.

This research was conducted in vitro, by considering only effect of media on fluoride release, whereas fluoride release may be modified by variables that are presented in vivo. So it is important to develop more in vivo studies with large sample size to assess different variables which influence physical and chemical behavior of restorative materials intra orally. To take into account the dynamic factors present in oral cavity, further clinical studies combining both qualitative and quantitative evaluation are necessary.

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