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A short term comparitive analysis of Fluoride release from a newly introduced Glass Ionomer Cement in deionised water and lactic acid

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Abstract:

*Background and objectives:*The ability of Glass ionomers to release fluoride exerts an anticariogenic effect, thereby reducing the possibility of recurrent caries and promoting remineralization. The purpose of the study was to evaluate and compare the amount and pattern of fluoride release from three types of glass ionomer cements GC Fuji II, GC Fuji VII and GC Fuji IX in water (pH 7) and lactic acid (pH 5.2) for a period of 28 days at five intervals.*Methods:* Twenty cylindrical specimens of dimensions 5 mm diameter x 2 mm height were prepared from each restorative material (total of sixty specimens). The pH values of the individual storage solutions were determined. pH of lactic acid was adjusted to 5.2 and pH of deionised water was 7.0. Specimens were divided into six groups and were stored in the incubator at 37 ^{0}C. Common immersion regimes were followed for all six groups of restorative materials for evaluating the release of fluoride ions at two different P^{H}. Fluoride release was assessed for a period of 28 days at five intervals at the first, eight, fourteenth, twenty -first and twenty-eighth days. Fluoride ion concentration of these solutions was determined using a Fluoride ion Specific Electrode. *Results:* Data obtained was

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statistically analyzed. Statistical comparisons were performed using Analysis Of Variance (ANOVA) for multiple groups and Student's "t" test for two group comparisons. A P-value of 0.05 or less was considered for statistical significance. Specimens showed statistically significant fluoride ion release profiles in both deionised water and lactic acid. *Interpretation and conclusion:* The pattern of fluoride release from all the restorative materials was similar. An "initial fluoride burst" was seen for the first few days after being placed in the storage solutions. The amount of fluoride released by GC Fuji VII was statistically highly significant on 1st and 7th day when compared to GC Fuji II and GC Fuji IX. P^{H} of the environment affected the amount of fluoride released, the amount of fluoride release in lactic acid was considerably greater than in deionised water. The total amounts of fluoride released from the three glass ionomers were statistically insignificant for 28 days.

Key words: Glass ionomer cement; Fluoiride Ion release; pH changes; caries control; minimal intervention.

Introduction:

Secondary or recurrent dental caries is by far the most frequent reason for replacement of restorations. Secondary caries initiation and propagation was found to be significantly reduced when Glass ionomer restorations were placed. This favorable result has been attributed in part to the release of high concentrations of fluoride ions (1)

Fluoride acts in several ways to prevent caries. Many hypotheses have been proposed to account for the anticaries effect of fluoride. It inhibits demineralization and promotes remineralisation, thus encouraging repair or arrest of the carious lesions. Depending on its concentration and pH, fluoride can exert a bactericidal or anti enzymatic effect which might reduce the bacterial acid production. (2, 3)

Since the introduction of silicate cements, fluoride release from restorative materials have been advocated as having the ability to prevent secondary or contact surface caries. Glass ionomer cements and their modified formulations are the main fluoride releasing materials used today. (4)

Conventional Glass ionomer cements represent the oldest category of GIC and have the disadvantage of inferior mechanical properties (5). GC Fuji II is the oldest conventional Glass ionomer restorative material, having disadvantages of poor strength, poor aesthetics and high technique sensitivity. (6)

To overcome this, newer, (GC Fuji IX) more-viscous, esthetic reinforced Glass ionomer cements were specifically developed for the use in atraumatic restorative treatment(7). The relatively higher viscosity is a result of the addition of poly acrylic acid to the powder and fine grain size distribution. The setting reaction proceeds in accordance with the usual acid base reaction typical of GICs. Their surface hardness is similar to that of fine particle hybrid composites and their abrasion resistance is decisively superior to that of traditional GIC. They have the ability to neutralize the salivary acids, by buffering the lactic acid via the release of chemical ions. (8)

Recently, a new generation of Glass ionomer material, GC Fuji VII (GC Fuji Triage) has been introduced. It has a self-bonding capability to the enamel in a wet environment. The unique features are low viscosity, high filler content, optional command set, radiopaque, biocompatible and with a very high fluoride release. (9)

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 (10). The predominant factors controlling the stability of the enamel apatites will be the pH and the concentration of fluoride in the surrounding solution. A pH decrease from neutral to critical pH (5.5) in the oral fluids, it will result in a dramatic increase in the solubility of the enamel apatites. A pH drop of one unit within the pH range 4.0 to 7.0 gives rise to a seven-fold increase in the solubility of the hydroxyapatite. (11)

Considering the above aspects, the present study was undertaken to evaluate and compare the amount and pattern of fluoride release from three types of Glass ionomer cements for a period of 28 days at five intervals and to evaluate the effect of change of pH on fluoride release in deionised water (pH 7.0) and lactic acid (pH 5.2) in an effort to simulate the critical pH.

Methods:

Sixty cylindrical specimens of dimensions 5 mm in diameter and 2 mm in height were prepared from the restorative materials GC Fuji II, GC Fuji VII and GC Fuji IX and were divided into six groups of ten each in two storage media.

The pH values of the individual storage solutions were then determined. These determinations were carried out using a Digital pH meter that had been calibrated with a standard buffer. pH of lactic acid was adjusted to 5.2. All the specimens were stored in the incubator at 37^0 C.

Common immersion regimes were followed for all six groups of restorative materials for evaluating the release of floride ions at two different pH.

Before each measurement, the specimens were removed from the beakers and rinsed with 1 ml of deionised water. This water is added to the previous storage solution, and each specimen was blotted dried and then returned to a new plastic container with fresh storage media.

Fluoride release was assessed for a period of 28 days at 5 intervals at the first, eight, fourteenth, twenty -first and twenty- eighth days.

Fluoride measurement

Fluoride ion concentration of these solutions was determined using a Fluoride ion specific Electrode (720A Orion Research Inc, Boston M.I. USA) calibrated immediately before use. The electrode slopes were checked every day and after every 15 samples. By doing so, the instrument was standardized.

Fluoride in the sample solutions was determined with the addition of Total Ionic Strength Adjustment Buffer (TISAB) to provide constant background ion strength, decomplex the fluoride and stabilize the pH of the solution. The TISAB contains 2% CDTA (1.2 cyclo hexane diamino tetra acetic acid),a metal chelating agent, that preferentially decomplex fluoride from the polyvalent cations, therefore making fluoride available for measurement.

Results :

The fluoride ion release profiles in deionised water and Lactic Acid at pH 5.2 from GC Fuji II, GC Fuji VII (GC Fuji Triage) and GC Fuji IX for a period of 28 days at five intervals were recorded. The fluoride ion release profiles were tabulated in ppm.

Graph 1,2,3 and 4 illustrates Comparision of Fluoride release between lactic acid and water in Fuji II, Fuji VII and Fuji IX provides descriptive information on fluoride release at different time intervals. Unpaired “t” test and one way ANOVA was used. Resulting p< 0.001 was highly significant. The greatest amounts of fluoride the materials released was in lactic acid. There was a significant difference (p<o.oo1) in the amount of fluoride released from all the materials in lactic acid Vs deionised water.

All the materials evaluated in this study released fluoride during the entire period of the experiment. Although great differences in the amounts of fluoride released exist, the pattern was similar in all media. The greatest amount of fluoride release was in first 24hrs.

Inter Group Comparision

On Day 1, Fuji VII released the highest amount of fluoride and the second highest release of fluoride was by Fuji IX followed by Fuji II. The release of fluoride between Fuji VII and Fuji II and Fuji VII and Fuji IX were statistically highly significant. The release of fluoride between Fuji II and Fuji IX were not statistically significant.On Day2, also Fuji VII released the highest amount of fluoride followed by Fuji II and Fuji IX.

On the 14th, 21st and 28th day, the amount of fluoride released from Fuji VII did reduce when compared to Fuji IX and Fuji II.The total amount of fluoride released by Fuji II, Fuji VII and Fuji IX during the inter-group comparision was statistically insignificant. Comparision and one way Analysis Of Variance (ANOVA) indicated that the relative amount of fluoride release was dependent on both the material and the environment.

Discussion :

Conventional Glass-ionomers have the capacity to buffer storage solutions and release a variety of matrix-forming ions, partly depending on the chemical composition of the glass employed in their fabrication, and partly on the pH of the surrounding medium. Acidic storage media lead to greater amounts of ion being released, and also to a change in relative amounts of the ions (2). Bearing these facts in mind, this study was carried out to evaluate the amount as well as the fluoride release profiles of GC Fuji II, GC Fuji VII and GC Fuji IX at two storage medias, that is water and lactic acid at pH of 7 and 5.2 respectively.

In our current experiment, lactic acid (0.02 mol l^{-1}) concentration was chosen since it is the one used in the impinging jet acid-erosion test of the current ISO standard and has been used previously in similar studies evaluating the neutralizing ability of restorative material(12,13). Lactic acid solutions of strength (pH of 5.2) along with de-ionized water (Control group) were used as immersion media for the Glass ionomer specimens.

A limited volume (10ml) of each liquid media was used to immerse the individual specimens in order to avoid build-up of ions in the surrounding liquid, which would in turn have an effect on the ion release rate. (14)

The analysis for fluoride release was done for 28 days based on the previous studies showing that the fluoride release by Glass ionomer cement is almost constant after the 28th day.(1)

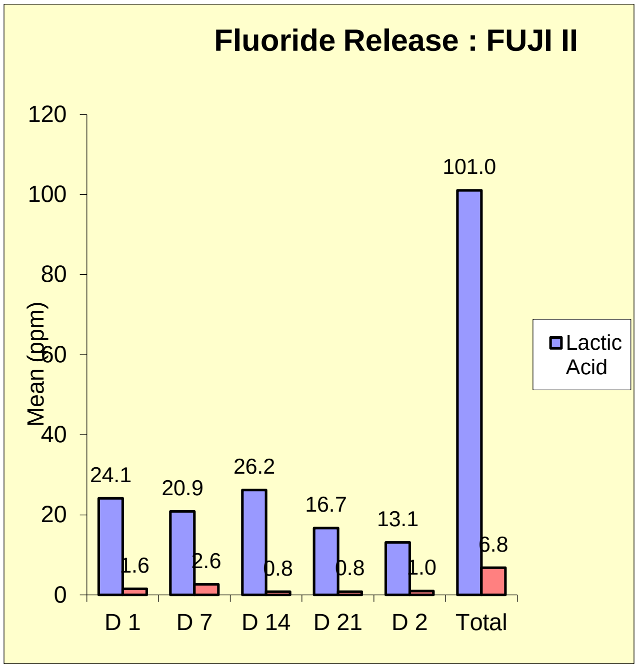
The “Fluoride Ion Specific Electrode” developed by Orion Research Laboratories USA (model: 94-09, 720 A) is used to estimate the fluoride content. Ion Selective Electrodes (ISE) is a membrane electrode that responds selectively to specific ions in the presence of other ions. These include probes that measure specific ions and gases in the solution. The basic ISE setup requires a probe, a meter capable of reading mill volts and a few additional reagents for controlling the ionic strength and pH of the sample.

Ion Selective Electrodes work on the basic principle of the galvanic cell by measuring the electric potential generated across a membrane by selective ions and then comparing it to a reference electrode, thereby determining the net charge. The strength of this charge is directly proportional to the concentration of the selective ion.

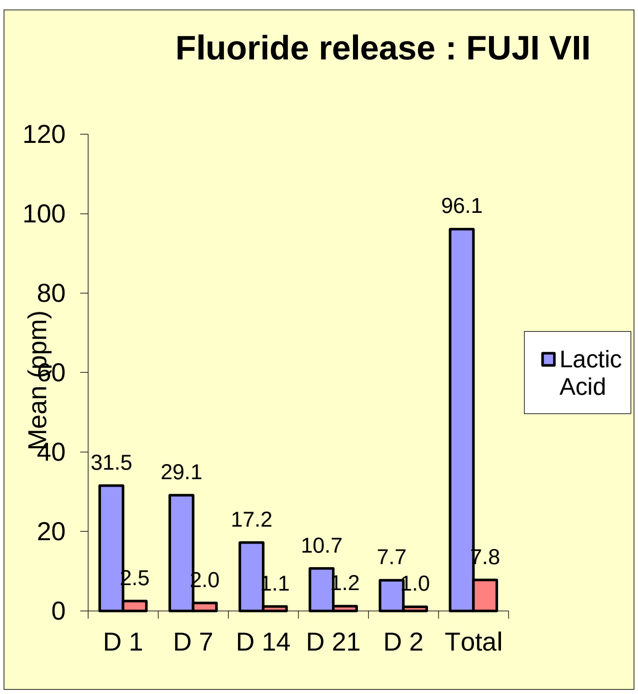
Kuhn and Wilson indicated the existence of three mechanisms concerning fluoride release from Glass ionomer cements; superficial rinse, diffusion through pores and micro fractures and mass diffusion. However, in a more recent study Billington RW, Williams JA, Pearson GJ concluded that for fluoride ions, diffusion seems to be a controlling process, at least for the first 24 hours (14). Grisp S, Lewis BG, Wilson AD suggested that fluoride is released from Glass ionomers as F, Alf or as fluorophosphates compounds, principally derived from glass particles that had no reaction at mixture time. (15)

The fluoride release of GIC’s depends partly on the type of cement, the particle size, fluoride content of the glass, P/L ratio mixing, setting times, pH and temperature of the environment. (16, 17)

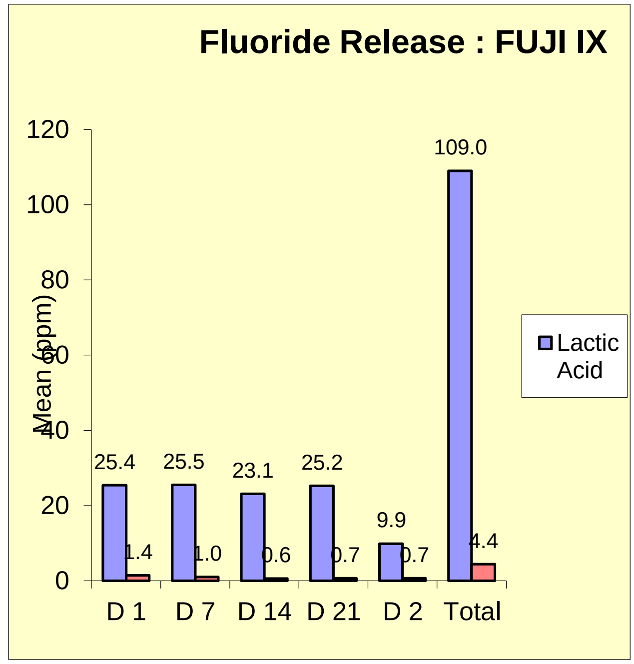
Graph 1



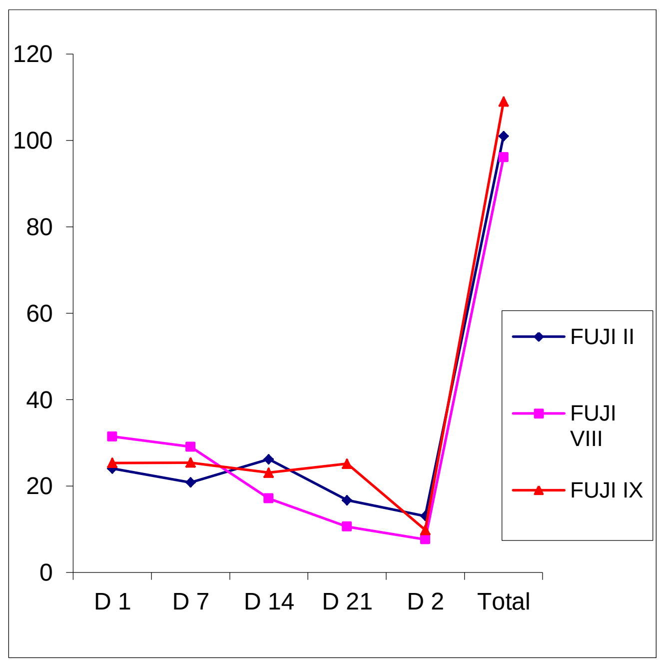
Graph 2



Graph 3



Graph 4: Fluoride release in different materials



The elution of fluoride occurs as two different phases. The first is characterized by an initial burst of fluoride release from the surface, after which the elution is markedly reduced. The second phase in which small amounts of fluoride continue to be released for periods up to 2 to 2.5 years. The acid base reaction of GIC and composition (glass particles, polyacid type, and P/L ratio) should influence the fluoride release more than the material type. (17)

Even traces of fluoride (0.02 to 0.12 PPM) in the demineralizing solution have been found to reduce the rate of dissolution of enamel and the mineral loss from enamel lesion.

Fluoride affects bacterial growth and metabolism both directly (eg: inhibition of enolase and ATPases) and indirectly (eg: intracellular acidification). Higher amounts of fluoride release from glass ionomer materials also inhibit the pH drop to a significant extent. (16)

The common finding of all the evaluated materials in the results of this study was the similar pattern of fluoride release in both the storage media. The highest dissolution occurred during the first 24 hours. During the second week the fluoride release was substantially lower, but the materials continued to release fluoride until the end of 28th day. Many previous studies support this finding and this could be due to the two elution phases that occur. (3)

Glass Ionomer Cements release more fluoride when the environment is at lower pH, thus providing the greatest amount of fluoride when it would be most needed to prevent secondary caries. This was supported by the observation that the amount of fluoride released was significantly higher throughout at pH 5.2 by many times greater than at neutral condition. (18)

The significant difference in the amount of fluoride release from the materials in lactic acid and water could be attributed to the fact that the dissolution of the material was dependent on the solvent (19, 20). According to reports by Crisp, Lewis &Wilson glass ionomers release more fluoride in the acidic media. Also, Forsten has stated that a decrease in pH, increased the release of fluoride ions Glass ionomers. This increased dissolution could be because of the decrease in pH. (15)

The amount of fluoride release necessary for “curing” carious lesions and for anticariogenic effects has not been documented. Such therapeutic doses of fluoride may not exist and warrants further investigation. The content of fluoride in restorative martial should be as high as possible without adverse effects on physicomechanical properties and release should be as great as possible without causing undue degradation of the filling.

The continued presence of small amounts of fluoride in the aqueous phase around tooth will reduce the effect of local under saturation conditions during a drop in pH. Replenishment of the fluoride within the material will therefore enhance the anticariogenic activity of the Glass ionomer cement for extended period of time. (21)

Conclusion :

Within the limitations of the present study the following conclusions can be drawn:

1. Fluoride release occurred for all the three materials GC Fuji II, GC Fuji VII (GC Fuji Triage) and GC Fuji IX for 28 days in both the storage media that is both deionised water and lactic acid.
2. The pattern of fluoride release from the materials was similar, “an initial fluoride burst” was seen for the first few days after being placed in the storage solutions.
3. The amount of fluoride released by GC Fuji VII was statistically highly significant on 1st and 7th day when compared to GC Fuji II and GC Fuji IX.
4. pH of the environment affected the amount of fluoride released . The amount of fluoride release in lactic acid was considerably greater than in deionised water.
5. The total amount of fluoride released from the three glass ionomers were statistically insignificant for 28 days

This study is an attempt to evaluate the amount and pattern of fluoride release in Glass ionomer cements in neutral as well as critical pH. In the light of present findings as well as documentary evidence, it seems that the ability of Glass ionomers to raise the pH and release fluoride and other cariostatic ions would exert an anticariogenic effect, thereby reducing the possibility of recurrent caries and promoting remineralization.

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