Fluoride release in glass ionomers

Geisa Delácio Gnipper[1]
Halim Nagem Filho[2]
Haline Drumond Nagem[3]

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ABSTRACT

The aim of this study was to evaluate in vitro fluoride release of three glass ionomers used as foundation (Fuji Ortho LC. Vidrion C and Vitremer C) in pre-established intervals of time (1h, 3h, 24h and then daily up to 14 days). Fifteen specimens were made for each glass-ionomer analyzed. They were suspended individually in recipients containing 30 ml of deionized water. At each interval the lids of the recipients in which each specimen was in suspension were transferred to a new recipient with equivalent amount of deionized water. Fluoride was analyzed with the electrode (Orion 9409) after buffering with Tisab III. The results showed the larger initial and final release for the glass-ionomer Vitremer Luting Cement followed by Vidrion C and Fuji Ortho LC. In the intermediary period there was an inversion of the values of release from Vidrion C in relation to Vitremer Luting Cement. The cement Fuji Ortho LC was the material that presented the smallest liberation rate during the whole experimental period.

Uniterms: cements; glass ionomers; fluoride.

1 MSc in Dentistics - UNITAU
2 Professor, Dental Materials - USC
3 Ph.D., Dental Materials USC

Universidade do Sagrado Coração
Rua Irmã Arminda, 10-50
17011-160
Bauru – S. Paulo
Tel: 14- 2357257
Email: spesquisa@usc.br

Universidade de Taubaté
Rua Expedicionário Ernesto Pereira, 110
12020-330
Taubaté- S.Paulo
Phone: 12-2254149

INTRODUCTION

Although introduced in England less than three decades ago by Wilson & Kent (1972) ionomeric cements are, perhaps, among the most useful and important materials for clinical use due to its application multiplicity. Containing fluoride in its original composition these cements called the attention of researchers and clinics due mainly to its properties of adhesivity to the dental structure and to the release of fluoride, becoming marginal sealing and potential anticariogenic compound (Christensen, 2000). They are used as cements, restoratives, filling and lining material, bases, sealant of fossules and fissures or orthodontic cements (Mount,1999)

The anticariogenic properties of cements are of utmost importance because of the relapse of caries is responsible for the majority of poor results related to crowns and fixed prosthesis and, furthermore, the accumulation of bacteria plaque close to orthodontic appliances can lead to enamel demineralization (Forss, 1990; Gao, et al. 2000). Forsten (1977) conducted one of the first studies on fluoride release by glass ionomers cements, comparing the property of this material to that of silicate cements. Greater values for ionomers were due to the greater amount of fluoride in its compositions, notwithstanding its lower solubility. Afterwards other authors conducted several studies (Creanor, 1994; Deschepper et al. 1991) using however different methodologies that allow just quantitative comparisons among results.

Fluoride release has been a key point among researchers and the properties related to this phenomenon should be investigated (Cehreli et al, 2000.; Peng et al. 2000; Lee et al, 2000). The heterogeneity in the formulation of ionomers is another reason that demands the previous knowledge of the properties of each compound in order to select the product and the technique of manipulation aiming to avoid or decrease the negative outcomes (Mount, 1999). The aim of this study is to evaluate the rate of fluoride ions release in three products commercially available (*Fuji Ortho LC*, *Vidrion* C e *Vitremer Luting Cement*) in periods previously determined.

MATERIALS AND METHOD

The commercial products used in this study were the chemical ionomeric cements *Vidrion* C (SS White) and *Vitremer Luting Cement* (3M) and the photoactivated cement *Fuji Ortho LC* (GC).

Disk shaped Teflon matrixes were prepared with 4 cm of diameter with a central perforation of 10mm and 2mm tick. Each specimen had an area of de 7.854mm^2. A cut was made in the matrix, from center to edge to allow the introduction of a nylon filament used to fix the specimen to the lid (Couto Jr, 1997).

The ionomeric cements were dosed and manipulated according to the recommendations of the manufacturers. The resulting powder was weighted in an analytical scale (Marte, model AS 1000). The rate powder/liquid for the entire sample was standardized by weight due to the importance of the fluoride content, preserving the proportion indicated in the writing directions of each product. For confection of the samples the Teflon matrix was isolated whit a thin layer of liquid Vaseline and, in the cleft, the nylon filament was inserted 3-mm inward to the matrix. The samples were processed in refrigerated environment at 23+1ºC and the mixture time of materials varied according to the instruction of the manufacturer. The cement was introduced in the matrix of Teflon and covered with a glass laminula and than pressed against the glass plate

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on which the matrix was laying in order to determine the thickness of the specimen.

A photopolimerizer of 400mW/cm2 (Fibralux-Dabi Atlante) was used for 40s in each side of the ionomeric cement *Fuji Ortho LC*. In the chemical activated cements (*Vitremer Luting Cement* and *Vidrion* C) another glass plaque was placed over the slide and the compound was pressed with a clamp. A minimal period of twenty minutes was needed after starting with the mixture to attain the adequate setting time to allow the removal of the specimen from the matrix, which was made by manual pressure. Fifteen specimens were made for each analyzed material.

The study started keeping the glass ionomer cement specimens in suspension by the nylon filament fixed to the cap in such a way the specimens did not touch the recipient. Selected pre-determined time intervals were 1h, 3h, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14 days. At every interval the lids of the recipients, in which each specimen was suspended, were transferred to a new recipient with equivalent quantity of deionized water. This procedure was repeated in the standard conditions amounting to a period of 14 days.

At the moment of reading the results it was added 3.0 ml of TISAB III (*Total Ionic Strength Adjuster Buffer-Analion*) in the recipient to guarantee an environment with constant ionic power, to decomplex the fluoride and to adjust the pH of the solution. An ion analyzer (Mettler Delta 350) was used in which it was fixed a specific electrode for fluoride ions (Orion, model 94-09) and another for reference (Orion, model 94-04).

All readings were made under magnetic stirring (magnetic stirring Fanem- model 257) with stirring bar to prevent air bubbles in the core of the solution. The equipment was calibrated with two standard 1 and 10-ppm sodium fluoride solutions prepared with Tisab III. This standard was checked before each reading. The equipment itself warned in case a new calibration was necessary. Values obtained were expressed in ppm and all steps described above were repeated at each reading totaling 16 readings for each specimen. Results were submitted to test of Kruskhal-Wallis and Friedman, non-parametric tests, tests for comparison of the variability among tested materials in the pre determined time intervals.

RESULTS AND DISCUSSION

Cements used in this study differ among themselves in the formulation and these differences can be seen in the superficial energy, in the fluoride content and in the porosity of these materials, affecting the rate of fluoride release (Khun & Wilson, 1985).

The statistic test is made by the median and the semi-amplitude of the values for release of fluoride ion (ppm) according to the tested material and the time interval. Results can be seen in TABLE 1.

TABLE 1 - Median and total semi-amplitude of the release of fluoride (ppm) according to the material and the period of evaluation and the respective results of statistic test of Kruskhal-Wallis and Friedman

	Material			
Period	*Vitremer Luting Cement*	*Vidrion*-C	*Fuji Ortho LC*	Result Kruskhal-Wallis
1 hour	14.55± 2.55 Cf	7.12 ± 0.91 Bi	1.56 ± 0.37 Af	39.13 (P<0.01)
3 hours	2.14 ± 0.54 Bd	3.50 ± 0.35 Cg	0.65 ± 0.13 Ad	39.13 (P<0.01)
1 day	3.88 ± 0.57 Be	4.80 ± 0.48 Ch	1.55 ± 0.38 Af	38.96 (P<0.01)
2 days	1.92 ± 0.46 Bd	2.50 ± 0.40 Cf	0.92 ± 0.29 Ae	35.68 (P<0.01)
3 days	1.29 ± 0.25 Bc	2.40 ± 0.59 Cf	0.65 ± 0.21 Ad	39.13 (P<0.01)
4 days	0.85 ± 0.21 Bbc	1.56 ± 0.33 Ce	0.41 ± 0.16 Acd	39.13 (P<0.01)
5 days	0.83 ± 0.19 Bbc	1.46 ± 0.24 Ce	0.42 ± 0.15 Acd	39.13 (P<0.01)
6 days	0.67 ± 0.19 Bc	1.11 ± 0.08 Cd	0.32 ± 0.16 Abc	39.13 (P<0.01)
7 days	0.62 ± 0.07 Bc	1.11 ± 0.17 Cd	0.23 ± 0.15 Ab	39.13 (P<0.01)
8 days	0.39 ± 0.08 Bab	1.05 ± 0.18 Cd	0.20 ± 0.10 Ab	38.53 (P<0.01)
9 days	0.38 ± 0.07 Bab	0.64 ± 0.22 Cc	0.18 ± 0.06 Ab	39.13 (P<0.01)
10 days	0.31 ± 0.07 Ba	0.48 ± 0.05 Cb	0.18 ± 0.05 Ab	39.13 (P<0.01)
11 days	0.28 ± 0.06 Ba	0.44 ± 0.09 Cb	0.14 ± 0.06 Ab	38.79 (P<0.01)
12 days	0.28 ± 0.05 Ba	0.37 ± 0.13 Cb	0.14 ± 0.09 Ab	34.93 (P<0.01)
13 days	0.17 ± 0.06 Aa	0.25 ± 0.14 Bb	0.19 ± 0.12 Ab	21.28 (P<0.01)
14 days	0.16 ± 0.06 Ca	0.08 ± 0.04 Ba	0.04 ± 0.02 Aa	38.87 (P<0.01)
Result	579.71	896.25	188.85	
Friedman test	P<0.01	P<0.01	P<0.01	

- Medians followed by a same capital letter do not differ regarding the material in a given period (P>0.01)
- Medians followed by a same letter do not differ regarding the period in a given material (P>0.01)

The capital letters facing each time interval of a given material show that in the first and in the last period *Vitremer Luting Cement* was the cement with greater rate of fluoride release, followed by *Vidrion* C and *Fuji Ortho LC*. In the intermediate periods – 3 hours and 12 days – there was an inversion in relation to *Vitremer Luting Cement* and *Vidrion* C. In the 13th period *Vidrion* C continued to show greater values in comparison to the other two cements that had similar rates of fluoride release. In relation to the data above it was possible to observe that the ionomeric cement chemically activated, in the later periods (3 days and 12 days) showed the greatest rate of release due probably to its own formulation.

In the first hour the *Vitremer Luting Cement* showed the greatest rate of release of ion fluoride, followed by *Vidrion* C, which shows half this value, and later the *Fuji Ortho LC* cement whit 1/10 of the magnitude of the *Vitremer Luting Cement*. The greater rate of fluoride release can be due probably to a greater quantity of fluorets in the composition of *Vitremer Luting Cement* in relation to the other cements (*Vitremer,* 3M, 1994)

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The low rate of release of fluoride ion by *Fuji Ortho LC* in the first moment sounds as a paradox but, in reality, means that the quantity of fluorets in the composition accumulated in the surface, notwithstanding the initial low values, seems to have no relevance as mention Forsten (1977) who considers the longevity of release the most important factor. Furthermore, the ideal rate of fluoride absorbed by tooth has not yet been determined (*Vitremer*, 3M, 1994). The nature of the process that controls the release of fluoride in glass ionomeric cements is not yet well established and thus many theories arise. In several studies the cumulative quantity of fluoride released in the ionomeric cements was linear against the square root of time Derkson et al., (1982) believe that the release is controlled by a diffusion phenomenon. Tay & Braden (1988) report that possibly two processes are involved: a rapid one related to surface release and another, slow and continuous, represented by diffusion of volume; Wilson (1985) add to these two processes a third one: a diffusion through pores and fissures in the material and the tendency the fluoride has to release itself preferably from the matrix of the cement possibly in the form of sodium fluoret (El Mallakh & Sarkar, 1990), aluminum fluoret and fluorphosphate (Crisp et al. 1976). For this reason it is not possible to assure that the rate of ion fluoride release from the *Fuji Ortho LC* is not sufficient to the prevention of caries.

Although the release potential seems to be greater for resin-modified ionomers the marked reduction in the release rate in the first 24 hours indicate that the ions of the external layer have depleted and the ions arrested inside the resin mass have significant difficulty to be released. In this period the conventional cement *Vidrion* C, chemically activated, has a greater performance with a less marked reduction probably due to the fact that leaching ions inside the porous mass have already initiate its liberation. The resin-modified glass ionomer cements contain resin components that restrain the release of fluoride ions. For this reason the released amount is smaller than that of the conventional ionomers. However, they show greater values if compared to composite resins.

The deceleration of the rate of released ions shows different tendencies for the three materials in the tested periods. The results of the test of Kruskhal-Wallis for comparison of variability show a significant reduction in the release of fluoride when compared to the time intervals.

In all cements the greater values were observed in the time interval of one hour followed by a marked decline in the 3 hours interval and a restoration in the 1-day period. This means that the released ions are a result of the erosion of the superficial area. The recuperation is due to the ionic diffusion of the body of the material.

TABLE 2 - Differences in the release of fluoride in the materials in relation to the studied periods (C>B>A)

	hours		days													
Material Period	1	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Vitremer L. C.	C	B	B	B	B	B	B	B	B	B	B	B	B	B	A	C
Vidrion C	B	C	C	C	C	C	C	C	C	C	C	C	C	C	B	B
Fuji Ortho LC	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

For the remaining time intervals the slow decline and the time span differ for *Vidrion* C in comparison to the other materials. This cement had shorter periods of decline (observed every two days) in relation to *Fuji Ortho LC* and *Vitremer Luting Cement*, which had a greater span (every three days) making the steps more gradual.

The mass of the cement Vidrion C, being probably more porous, when the liquid enters makes it easier to remove the leaching fluoride ions. This difference may define, on the one side, the better position of *Vidrion C* regarding fluoride release in the environment; however, it is possible that its mass might become more soluble provoking erosion. *Vitremer Luting Cement* showed a greater release on the first and last day. This demonstrates that this material has rapid release of its superficial ions in the first hour and that the decrease in fluoride ions release is slower in the last day. This leads to the potential conclusion that this material has an optimum performance since the release of ions is constant and slow along the time, although significant in the first day. The *Fuji Ortho LC* cement showed the smaller rate of release along the studied periods. Facing the Freedman's test ($p< 0.01$) the results of the three types of glass ionomer cements showed significant differences. The greater value was that of the conventional ionomer *Vidrion* C, followed by *Vitremer Luting Cement* and *Fuji Ortho LC*. Hattab (1991) and Mcknight-Hanes, (1992) considered a direct proportional relation between porosity of the material and the rate of fluoride release. Another factor stressed by Momoi; Mccabe, (1993) is the type and amount of resin incorporated to the photoactivated glass ionomer cements. The greater amount of fluoride ions released by the chemically activated ionomer *Vidrion* C is due to the greater porosity of its mass and the absence of resin, which facilitates the diffusion of ions.

The photoactivated systems offer the advantage of quick hardening, superior mechanical properties and less solubility. On the other hand, studies *in vitro* revealed less release of fluoride ions (CAO 1994).

In this way, it is possible that the property of fluoride release in these three materials is considered appropriate for clinical use and that possible differences in other properties of the ionomeric cements can be the determining factors for the selection of a given material in the daily life at the dentist's office.

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CONCLUSIONS

1) In the initial period (1 hour) *Vitremer Luting Cement* showed the greatest rate of fluoride ion release, followed by *Vidrion* C and *Fuji Ortho LC*;

2) The three tested materials showed different values for fluoride ion release in the first time intervals with a marked decrease for *Vitremer Luting Cement* and a more gradual one for *Vidrion* C and *Fuji Ortho LC*;

3) Despite the tendency of the release rate to be constant, in the intermediate time intervals *Vidrion* C showed variation in the rate in longer periods (three days) than the other cements;

4) As a whole, regardless the time interval, the greatest fluoride ion release rate was found in the ionomeric cement *Vidrion* C.

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GNIPPER, Geisa Delácio; FILHO, Halim Nagem; NAGEM, Haline Drumond. Fluoride release in glass ionomers. *Salusvita*, Bauru, v. 20, n. 3, p. 35-42, 2001.