Orthodontic cements: Immediate protection and fluoride release

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Objectives: The objective of the authors was to evaluate fluoride release of 3 glass ionomer cements with immediate protection of fluoride varnish (Cavitine, SS White), divided into 3 groups: Group M (Meron, VOCO), Group V (Vidrion C, SS White) and Group KC (Ketac-Cem, 3M ESPE).

Methods: Fluoride release was measured during 60 days by means of an ion-selective electrode connected to an ion analyzer. After 4 weeks, the test specimens were exposed to a solution of 0.221% sodium fluoride (1000 ppm of fluoride).

Results: Results showed that the cements reached a maximum peak of fluoride release in a period of 24 h. There was a statistically significant difference between the amount of fluoride released after the applications of fluoride among the groups from the 31st to 60th day ($p > 0.05$).

Conclusion: The Vidrion C and Meron cements showed better performance to uptake and release fluoride when compared with Ketac-Cem cement.

Keywords: Glass ionomer cement. Fluoride release. Varnish.

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Cimentos ortodônticos: proteção imediata e liberação de flúor

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Objetivo: o objetivo desse estudo foi avaliar a liberação de flúor dos seguintes três cimentos de ionômero de vidro, com proteção imediata de verniz fluoretado (Cavitine, S. S. White): Meron / VOCO (Grupo M); Vidrion C / S. S. White (Grupo V); e Ketac Cem / 3M ESPE (Grupo KC).

Métodos: a liberação de flúor foi medida durante 60 dias, através de eletrodo íon seletivo conectado a um analisador de íons. Após quatro semanas, os corpos de prova foram expostos a uma solução de fluoreto de sódio a 0,221% (1.000ppm de flúor).

Resultados: os resultados evidenciaram que os cimentos atingiram o pico máximo de liberação de flúor com 24h após a presa inicial. Houve diferença estatisticamente significativa entre os grupos, quanto à quantidade de flúor liberado após as aplicações de flúor, do 31º ao 60º dia (p > 0,05).

Conclusão: os cimentos Meron e Vidrion apresentaram maior capacidade de captação e liberação de flúor, em comparação ao cimento Ketac Cem.

Palavras-chave: Cimento de ionômero de vidro. Liberação de flúor. Verniz.

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INTRODUCTION

Decalcifications on the dental surfaces adjacent to brackets occur frequently in orthodontic treatments.[18] In order to reduce the occurrence of demineralization, fixation of devices must be made using a material that is capable of releasing fluoride, providing adequate bonding to enamel and to the brackets[5].

Although glass ionomer cement (GIC) is a widely used material in orthodontics, some of its properties are not yet completely satisfactory.[15] Therefore, it is extremely important for orthodontists to know the properties of the material that they use in office, being aware both of their advantages as well as their limitations.[1] During the initial setting stage, glass ionomer cements are more susceptible to hygroscopic alteration of the environment. It may suffer syneresis and imbibition processes, which are the loss or gain of water from the external environment, respectively. This contamination affects the physical properties of bonding and increases the chances of the material disintegrating. To prevent this from occurring, immediate protection of the surfaces of GIC with sealing materials such as varnishes is recommended.[4,10] It takes 24 h for GIC to set completely and reach maximum strength force[21]. This occurs due to the extremely slow release of aluminum ions from the glass powder. Since the material is not completely hardened, the first 24 hours after application of this material are critical.[19]

Recent studies have shown fluoride release from ionomer materials which were exposed to a fluoride recharge, for a short period of time and at intervals of days,[17] or for only one day of exposure.[8] The aim of this study was to test fluoride release before and after recharge of conventional glass ionomer cements.

MATERIAL AND METHODS

To evaluate fluoride release, the materials were divided into 3 groups: Group M (Meron, VOCO, Cuxhaven, Germany), Group V (Vidrion C, SS White, Rio de Janeiro, Brazil) and Group KC (Ketac-Cem, 3M ESPE, Seefeld, Germany).

The test specimens were fabricated using silicone molds measuring 4 mm in diameter and 4 mm high (Fig 1). The material was inserted into the molds with the aid of a syringe (Centrix, DFL, Rio de Janeiro, Brazil), preventing the formation of bubbles.

The surface of the test specimens was covered with glass slides under digital pressure, planarizing the surface of the material. The cements were kept under pressure for 10 minutes. The application of fluoride varnish (Cavitine, SSWhite, Rio de Janeiro, Brazil) on the surface of the GIC cylinders was performed immediately after removing the excess of cement and they were lightly dried with jets of air using a triple syringe. All the materials were manipulated by a single operator in accordance with the manufacturer's instructions.

Thirty test specimens were made, ten specimens for each one of the cements, which were protected with varnish and kept in a humidifier at 37 °C and 100% of humidity for 30 minutes. After this period, 2 test specimens were placed in 8 mL of deionized water through the Milli-Q purification system (Millipore, Bedford, MA, USA) and placed in a glass receptacle. The glass receptacles were kept in an oven at 37 °C (bacteriological oven, type B2C, number 105) during the study. The test specimens were lightly dried with absorbent sheets of paper every 24 h and the water of each receptacle was changed. This procedure was carried out to prevent the accumulation of fluoride and to evaluate daily fluoride release.[14]

To wash the test specimens 8 mL of solution and 2 mL of deionized water were mixed and diluted 5 times and adjusted with 50 mL of total ionic strength adjustment buffer (TISAB). The concentrations of fluoride were analyzed through an ion-selective electrode (Thermo Orion Model 9609, Orion Research Inc., Boston, MA) connected to an ion analyzer (Ph/ion, 450 M, Analyzer, São Paulo, Brazil). The electrode was daily calibrated with standard fluoride solutions of 0.05, 0.10, 0.19 ppm. Readings were made to assess the concentrations of fluoride release from each material and the data transformed into $\mu g/cm^2$ in order to show the amount of fluoride released per area of the test specimen. Fluoride release was measured after 1 h and 2, 3, 7, 14, 21 and 28 days.

After 4 weeks, the test specimens were rinsed with deionized water for 20 seconds and the surface was lightly dried with disposable absorbent paper and exposed to a solution of 0.221% sodium fluoride (1000 ppm of fluoride) (School Pharmacy, Federal University of Rio de Janeiro, UFRJ) on day 28 for 5 minutes and then rinsed with deionized water for 20 seconds.

Two test specimens were placed in 8 mL of deionized water in a glass receptacle and fluoride release was measured after 24 h and 48 h (on days 29 and 30) to observe the release time of absorbed fluoride. On days 30, 31 and 32, new fluoride recharge was made, as previously described, and evaluated 24 h after the procedure (days 31, 32 and 33) to observe capacity of maintenance of recharge. New evaluations were

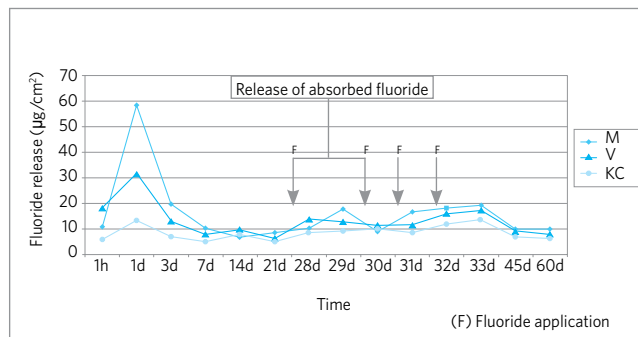**Figure 1** - Silicone molds used to fabricate the test specimens.

Figure 2 - Amount of fluoride released for each one of the cements during the period assessed.

made after 45 and 60 days with the purpose of verifying the behavior of the cements after 15 and 30 days of recharge. Deionized water was used instead of distilled water, since deionized water does not have ions and the presence of ions might have interfered in the results.

Analysis of variance, multiple comparison (ANOVA) and Kruskal-Wallis tests were used for the evaluation between the groups with reliability at a level of significance of 0.05 to identify the statistical difference in fluoride release.

RESULTS

The amount of fluoride released by each cement during the period assessed is shown in Figure 2. The standard fluoride release was similar for the different cements assessed. All the materials showed greater fluoride release on the first day and a rapid decrease up to the seventh day, but there was a difference in the amount of fluoride released. Table 1 shows fluoride release of materials after daily changes of Milli-q water.

Table 2 shows fluoride release of materials after immersion in the sodium fluoride solution. On day 28, before application of fluoride, the amount of fluoride released from Vidrion was higher than for the other materials, but there was a statistically significant difference among the groups ($p < 0.05$).

On day 29, the first day after application of fluoride, there was a statistically significant difference

Table 1 - Fluoride release of ionomer cements during 28 days.

GIC	1 hour	1 day	3 days	7 days	14 days	21 days	28 days
M	10.58 (1.20)	58.43 (2.89)	19.50 (2.17)	10.03 (0.41)	6.60 (0.56)	8.28 (0.41)	10.03 (0.41)
V	17.91 (2.81)[a]	31.68 (2.84)[a]	12.73 (1.76)[a]	7.80 (2.26)[a]	9.39 (0.56)[a]	6.21 (0.68)[a]	13.77 (0.50)[a]
KC	5.65 (1.07)[b]	12.97 (2.80)[ab]	6.84 (0.48)[ab]	4.69 (0.16)[ab]	7.80 (0.33)[ab]	4.69 (0.16)[ab]	8.28 (0.16)[ab]

N=10, Mean (standard deviation), [a]($p<0.05$) compared to group M. [b]($p<0.05$) compared to group V. Significant statistical difference observed between groups for the same analyzed time.

Table 2 - Fluoride release of ionomer cements after application of fluoride.

GIC	28 days	29 days	30 days	31 days	32 days	33 days	45 days	60 days
M	10.03 (0.41)	17.51 (1.59)	8.75 (0.53)	16.79 (0.61)	18.07 (0.82)	19.02 (1.00)	9.55 (1.23)	9.75(0.81)
V	13.77 (0.50)[a]	12.74 (0.75)[a]	11.06 (1.51)[a]	11.30 (0.82)[a]	15.76 (0.82)[a]	17.19 (0.93)[a]	8.75 (0.91)[a]	7.99(0.93)[a]
KC	8.28 (0.16)[ab]	8.99 (0.50)[ab]	9.55 (0)[b]	8.12 (0.33)[ab]	11.38 (0.62)[ab]	13.45 (0.61)[ab]	6.76 (0.66)[ab]	6.13(0.71)[ab]

N=10, Mean (standard deviation), [a]($p<0.05$) compared to group M. [b]($p<0.05$) compared to group V. Significant statistical difference observed between groups for the same analyzed time.

among the groups (p < 0.05). On day 30, which corresponds to 48 h after the first recharge of fluoride, there was no statistically significant difference between the groups M and KC (p > 0.05).

There was a statistically significant difference between the amount of fluoride released after the applications of fluoride among the groups from the 31st day to the 60th day (p < 0.05). On days 32 and 33, all the cements showed greater fluoride release, which shows the capacity of uptake and accumulation of fluoride after recharge. On the 45th and 60th day, significant decrease of fluoride release was observed for the three cements with values close to the ones observed on the 7th and 28th day.

DISCUSSION

It has been widely reported that GIC or other materials that contain fluoride present a cariogenic inhibitory effect when compared with composites without fluoride, as observed by Kielbassa et al[12] and this inhibition is fundamental in orthodontic treatment. The fluoride solution used was at a concentration of 1000 ppm NaF, similar to the concentration of dentifrices used for dental toothbrushing, according to Okuyama et al.[16]

Fluoride release was evaluated for 4 weeks with the purpose of observing the performance of the material during this period, since patients with fixed appliances normally visit the orthodontist once a month. In this study, a protocol of daily water change was used to assess fluoride release, for this protocol is better than the accumulation of fluoride in a solution.[20]

Caves et al[3] reported that the type of cement, the geometric model and surface area may significantly influence fluoride release, but there is no standardized size for test specimens to assess fluoride release, which are diverse in other studies.[6] The present study used disks measuring 4 mm in diameter and 4 mm high.

Fluoride release found in glass ionomer cements was higher 24 h after initial setting and decreased after 3 and 7 days. After the 7th day, there was small variation and fluoride release was constant, which is similar to the findings of Komori and Kojima[13] and Kuvvetli et al[14] (Fig 1). This characteristic is clinically relevant for cementation materials and the 3 cements maintained a small difference of fluoride release after the 7th day. The cements that showed better performance were

Meron and Vidrion, which may mean a greater clinical effect for preventing enamel demineralization when compared with Ketac-Cem.

Meron cement showed good performance, which corroborates the findings of Akkaya et al,[2] a performance close to the one found for Vidrion cement and better than Ketac-Cem, which showed a lower value than the one found by Komori and Kojima.[13] Fluoride release of Ketac-Cem was significantly lower than the one found for the other 2 ionomer cements, but release showed to be detectable during the entire experiment which, according to Dijkman et al,[7] is fundamental during orthodontic treatment.

After one day of fluoride release, the 3 cements Meron, Ketac-Cem and Vidrion showed greater fluoride release when compared to the time interval of 1 h, which shows that these cements reach a maximum peak of fluoride release after 24 h of initial setting, with a statistically significant difference (p < 0.05). On the 7th, 14th, 21st and 28th day, the cements showed a similar fluoride release pattern, but with lower values than at the time intervals of 1 h, 1 day and 3 days. This shows that despite the three cements presenting lower values of fluoride releases after the 7th day, the values were detectable during the entire experiment.

The amount of fluoride recharge may depend on the capacity of intrinsic fluoride release of each material, since the sites occupied by intrinsic fluoride are fixed and limited inside them.[11] The cements that showed greater initial fluoride release presented greater fluoride release during the entire experiment, which suggests a greater capacity of fluoride recharge, being in agreement with the findings of Xu and Burgees.[22] Fluoride released after the period of exposure of recharge has a tendency to release the same amount as the initial period,[16] which may be observed during the application period of fluoride from day 29 to day 33. Fluoride release observed after 45 and 60 days showed values close to the ones observed on the 7th and 28th day, which suggests that, after these values, fluoride release tends to slowly diminish, being detectable after longer periods.

Material porosity may influence the amount of fluoride released before and after recharge, in accordance with Xu and Burgess.[22] Obviously, greater porosity enables greater diffusion of fluoride recharge and results in a larger amount of storage and release.

Resin-reinforced glass ionomer cements present less porosities than conventional GIC and therefore, lower fluoride release, which corroborates the findings of Komori and Kojima[13] and Kuvvetli et al.[14]

In an in vivo study, Hallgren et al[9] observed that brackets and bands cemented with GIC significantly increased the concentration of fluoride in saliva. However, it is suggested that the orthodontic bands should be regularly checked because fluoride release may not completely inhibit developing caries lesion in the bands, which may be loose or in areas that are without GIC.

CONCLUSION

It could be concluded that:

1) Immediate protection with fluoride varnish reduces the risk of syneresis and imbibition and do not inhibit fluoride release.

2) Meron and Vidrion cements presented greater capacity of fluoride uptake and release than Ketac-Cem cement.

3) The amount of fluoride release in the three cements increased after recharge. Thus, the use of fluoride mouthrinses is suggested as an alternative to increase the amount of fluoride released by GICs.

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