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# Influence of 0.05% sodium fluoride solutions on microhardness of resin-modified glass ionomer cements

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**Abstract** This study aimed to evaluate the influence of fluoride-containing mouthrinse solutions (Fluorgard and Oral B) on the superficial microhardness of two resin-modified glass ionomer cements (Vitremer and Fuji II LC). Fifteen discs-shaped specimens of each glass ionomer cement (Ø10 mm; 2 mm thick) were prepared, thereby forming two groups. After 24-hour storage in artificial saliva, the microhardness was measure and the data were recorded. Next, each group was divided into three subgroups (n = 5), according to the solution to be immersed in. Control specimens were kept in artificial saliva along the whole experiment. The test specimens were kept in mouthrinse solution for 30 days. Vickers surface microhardness was analyzed at predetermined evaluation periods: 24 h, 48 h, 7, 14, 21 and 30 days after specimens' preparation. Data were subjected to three-way ANOVA and to Tukey test ($p < 0.05$). A better behavior of Fuji II LC was observed and Fluorgard affected most the characteristics of the tested materials. It may be concluded that fluoride-containing solutions influenced the tested characteristics of materials, mainly of Vitremer.

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## Introduction

Dentistry has been changing its focus to new goals aimed at oral health promotion. All this became possible due to the understanding of the carious process dynamics, as observed in the white lesions of tooth surface demineralization, which could develop into cavities, remain stable or remineralize. In this way, it is possible to remineralize dental surface using different fluoride-containing topical agents, either as home-use mouthrinse or as solutions applied at the dentist's office, like fluoride-containing gels and varnish [1–3].

As an additional fluoride therapy, restorative materials with the ability to release fluoride into the dental structure were developed, such as the glass ionomer cement (GIC). More recently introduced, resin-modified glass ionomer cements (RM-GIC) claim to improve the mechanical properties of GICs [4, 5]. Both laboratory and clinical research have clearly demonstrated the ability of the resin-modified glass ionomer cements to release fluoride [6, 7].

Fluoride released from RM-GIC not only exerts an antibacterial activity [8, 9] but is also taken up by the tooth structures [10, 11] thereby reducing or preventing demineralization [12, 13] and promoting remineralization [14]. It may be assumed that the content of fluoride should be as high as possible but without adverse effects on the physical properties of the material, as degradation of filling [15].

Resin-modified glass ionomer cement is able to reactivate itself after successive exposures to outside fluoride-delivering sources (mouthrinse or dentifrices), which has been an important bacteriostatic method, associated to fluoride-containing mouthrinse [16, 17].

The use of fluoride-containing mouthrinse for daily oral hygiene is a feasible treatment option for remineralization of dental tissues, depending on the patient's risk of developing caries. However, routine usage of such solutions could alter or interfere with the characteristics of some restorative materials [18, 19]. Some mouthrinses with high ethanol contents may soften the resinous components of glass ionomers, affecting the restorations' hardness and therefore their longevity. Another substance found in mouthrinses is the phosphoric acid, which can affect the materials' surface characteristics [20, 21].

Studies demonstrated that glass ionomer cements could be recharged with fluoride treatment or daily toothpaste [22, 23]. Although topical application of fluoride gels and varnishes is an established procedure in preventive dentistry, forced fluoride recharging of RM-GIC may come at the cost of increased surface roughness and deterioration of the restorative material with time [24].

The fluoride released from and the uptake by resin modified cements was reported to be higher or similar than conventional glass ionomer cements [7, 25, 26].

It is therefore of paramount importance the conduction of research on fluoride-containing commercial brand gels and solutions that provide the expected effects, without compromising the restorative materials' esthetic results and mechanical properties of existing tooth restorations [18, 27, 28].

The aim of this study was to assess the influence of fluoride-containing solutions on surface microhardness of two resin-modified glass ionomer cements with time.

## Materials and methods

Two resin-modified glass ionomers cements (Fuji II LC and Vitremer) and two fluoride-containing solutions (Fluorgard and Oral B) were chosen for this study. The composition and specifications of the tested materials and solutions are displayed on Table 1.

A stainless steel matrix (10 mm in diameter; 2 mm thick) was used for specimen preparation. The resin-modified glass ionomer cements were mixed and manipulated according to the manufacturers' instructions. The glass ionomers were inserted into the matrix cavity in a single increment with a Centrix® syringe and covered with an acetate strip. In order to compact the material and prevent void and bubble formation, a microscopic slide with a 1.650 g weight on it was placed over the glass ionomer/matrix ensemble, thereby allowing the manufacture of specimens with smooth, highly flat surfaces. After 30 seconds, the weight was removed and the ionomer increment was light cured for 40 seconds through the glass slide, by means of the tip of a visible light-curing unit with a 450 mW/cm$^2$ output (XL-3000, 3M Dental Products, St. Paul, MN, 55144, USA). A total of thirty disc shaped specimens were manufactured, thereby forming two groups of equal size (n = 15), each corresponding to one of the tested materials. Microhardness measurements of the acetate-covered surface were performed at predetermined evaluation periods: 1 hour, 24 hours, 48 hours, 7 days, 14 days, 21 days and 30 days after immersion in fluoride or saliva solution.

Vickers hardness measurements were done using a micro-indentation tester (Microhardness Testers HMV-2, Shimadzu Corporation, Kyoto, Japan) with 50 gf load applied for 30 seconds. The specimens were individually fixed in a clamping apparatus and positioned in such a way that the test surface was kept perpendicular to the indentation tip. In each disc, 3 equally spaced indentations over a circle and not closer than 1 mm to the adjacent indentation or the margin of the

**Table 1** Tested materials and solutions

| Material/Solution | Composition | Manufacturer | Batch n. |
|---|---|---|---|
| **Vitremer** | Powder: fluoride aluminum silicate glass Liquid: HEMA-polyacrilic acid, water | 3M Dental products | 20010404 |
| **Fuji II LC** | Powder: fluoride aluminum silicate glass Liquid: HEMA-polyacrilic acid, water | GC Corporation | 0008011 |
| **Fluorgard pH = 4.20** | Sorbitol, Water, Polisorbate 20, Potassium sorbate. Sodium bi-phosphate, Phosphoric Acid, Sodium fluoride, Red Coloring | Colgate | nf |
| **OralB pH = 5.95** | 0.05% Sodium fluoride, Demineralized Water, Glycerin 96%, Cetylpyridium Chloride, Mint Essence, Sodium Saccharine, Metilparaben, Propilparaben, Coloring, Sodium Benzoate e Polyoxil 40 | Gillette do Brasil | X-043-2 |
| **Artificial Saliva pH = 7.00** | $K_2HPO_4$, 70% Sorbitol, NaF, KC1, Nad, $MgC1_2.6H_2O$, $CaC1_2$.2 $H_2O$, Nipagin, Sodium Benzoate, Hidroxietilcellulose, H2O qsp | Biochemistry department FFRP-USP | |

specimens were taken and the average was calculated. Then, for all evaluation periods, a microhardness mean value was obtained for each of the tested materials.

Right after the immediate-post-fabrication measurements, the discs were stored in water for one hour and, afterwards, microhardness measurement was accomplished. Next, each group (Fuji II LC and Vitremer) was randomly divided into three subgroups of five specimens, according to the solution to be immersed in. The control samples were kept in 5 mL artificial saliva during 30 days. The solution was changed daily. The experimental samples were kept in 5 mL of the fluoride solutions during 30 days. The solution was changed daily. Before each measurement, the samples were rinsed in distilled water for 1 minute and dried with absorbing paper.

Sample distribution and homogeneity were analyzed. As a normal and homogeneous distribution was observed, the data were submitted to three-way ANOVA parametric test. Multiple comparisons were done by Tukey statistical test at 5% significance level.

## Results

Data analysis revealed that the microhardness of glass ionomer cement was altered ($p < 0.01$) by both tested mouthrinses solutions (Table 2) and between the solutions, with Fluorgard showing higher alterations.

As regards the evaluated resin-modified glass ionomer cements, independent of discounting test solutions and the evaluation period, it was noticed that Fuji II LC yielded higher microhardness averages than Vitremer ($p < 0.05$). As for the evaluation periods, microhardness increased in the first 7 days and remained stable after 30 days.

When the interaction between the solutions and evaluation period was observed, the samples immersed in artificial saliva (control group) and in Oral B exhibited increasing microhardness values up to the 7$^{th}$ day and remained stable afterwards up to the 30$^{th}$ day. Samples immersed in Fluorgard showed no significant change in microhardness up to the 7$^{th}$ day and decreased significantly at the 30$^{th}$ day evaluation. All solutions behaved similarly for both analyzed materials.

## Discussion

The RM-GICs are widely used in dentistry, due to the fact that fluoride released from these materials effectively inhibits tooth demineralization in artificial carious solutions or gels [29, 30].

The concentration of fluoride release is higher during the first 24 hours, declines on the second day, and then gradually diminishes with time [26]. The high concentration observed in the first day is called as the "burst effect" of fluoride. The reason for the rapid fall of fluoride release during subsequent days is likely to result from initial burst of fluoride released from the glass particles as they dissolve in the polyalkenoate acid during the setting reaction.

However, the CIGs restorations are able to take up fluoride ions when exposed to relatively high fluoride concentrations and subsequently release these ions when exposed to low fluoride concentrations [31].

The use of fluoride-containing solutions as daily mouthrinses is quite widespread among dental patients, which may be considered an important manner of RM-GIC acquiring fluoride [7, 23]. However, it has been reported [17, 18, 32–34] that the constant use of such products interferes

**Table 2** Means and standard deviations of superficial microhardness (Hv) of different materials and interaction.

| | Vitremer | | | Fuji II LC | | |
|---|---|---|---|---|---|---|
| | Saliva | Fluorgard | Oral B | Saliva | Fluorgard | Oral B |
| **1 h** | **45.32**<br>( ± 3.77) | **35.26**<br>(± 4.06) | **25.20**<br>(± 8.46) | **45.28**<br>(± 3.81) | **43.16**<br>(± 8.90) | **39.20**<br>(± 4.78) |
| **24 h** | **55.26**<br>(± 8.49) | **43.48**<br>(± 7.41) | **35.84**<br>(± 4.78) | **55.46**<br>(± 7.78) | **42.84**<br>(± 3.21) | **45.36**<br>(± 6.81) |
| **48 h** | **53.38**<br>(± 7.25) | **36.80**<br>(± 7.11) | **40.96**<br>(± 4.98) | **57.56**<br>(± 6.61) | **40.06**<br>(± 5.16) | **50.30**<br>(± 6.58) |
| **7 days** | **62.18**<br>(± 11.72) | **31.54**<br>(± 5.89) | **43.68**<br>(± 3.96) | **60.22**<br>(± 9.55) | **41.84**<br>(± 14.75) | **52.54**<br>(± 8.71) |
| **14 days** | **66.12**<br>(± 12.00) | **24.32**<br>(± 3.80) | **41.30**<br>(± 5.58) | **57.90**<br>(± 9.28) | **31.30**<br>(± 4.73) | **46.24**<br>(± 6.45) |
| **21 days** | **63.02**<br>(12.08) | **30.46**<br>(± 2.78) | **38.82**<br>(± 8.48) | **58.42**<br>(± 7.50) | **31.44**<br>(± 2.88) | **45.36**<br>(± 2.76) |
| **30 days** | **58.54**<br>(± 8.91) | **26.00**<br>(± 3.88) | **36.16**<br>(± 4.91) | **57.74**<br>(± 7.18) | **30.78**<br>(± 2.25) | **41.96**<br>(± 3.07) |

on the properties of aesthetic restorative materials, such as glass-ionomer cements, compomers and composite resins.

This study observed that the tested mouthrinse solutions affected the surface microhardness of the tested materials. Similar results were observed in other studies related to fluoride-containing solutions, which noticed that the use of such solutions may affect the physical characteristics of glass ionomers, due to their composition and pH [35].

Surface disintegration is caused by a selective attack on the polysalt matrix among the residual glass particles [36, 37]. The polysalt matrix of the set cement results from the formation of contact cation-anion ion pairs or complexes between the carboxylic groups of the polyakenoic acid and metallic ions, especially trivalent aluminium, leached from the glass particles [38].

Other factor that can affect microhardness may be the pH of mouthrinse solutions. When exposed to an acidic environment, both conventional and resin-modified glass ionomer cements may release additional fluoride. This can result from the dissolution of matrix-forming constituents within the restorative material [39]. So, if the solutions present acidic pH, both influenced negatively the tested property, mainly for the Fluorgard. Furthermore, Fluorgard presented lower pH (4.2) than Oral B (5.95), due to the phosphoric acid in its composition, which probably decreased the microhardness of the tested materials. Similar results were reported by some studies [20, 21] which also observed that phosphoric acid as 1.23% APF gel produced an eroding action on restorative materials and also, to a lesser degree, the 2% NaF gel (without acidic components) [1, 36, 37]

Several studies [40, 41] have shown that such chemical erosion occurs when GIC are treated even for a short time with acidulated fluoride gels. Acidulated phosphate gels (APF) have also been shown to damage the surface of RM-GIC, although in a lesser extent (40, 42, 43). These observations are not surprising as the polysalt matrix of GIC becomes quite soluble in acidic solutions compared to neutral solutions [38].

Some authors [44, 45] also reported that the acid of the bacterial biofilm affects the surface of composite resins causing superficial alteration in the same way as the application of acidic fluoride phosphate on esthetic materials. The alterations caused by fluoride-containing mouthrinses may be restrained by the restorative material's composition. Diaz-Arnold et al. [46] and Kanchanavasita et al. [47] evaluated four glass ionomer cements (Ketac-Fil, Ketac-Silver, Photac-Fil and Fuji II LC) exposed to acidulous fluoride gel, and they observed that surface hardness decreased only for Fuji II LC and Photac-Fil. The same alterations occurred with glass ionomer cements stored in artificial saliva and distilled water. Similar results were found for glass ionomer cements that were stored in solutions simulating food and in sodium hydroxide [48].

Based on the results of this study it is suggested that, for resin-modified glass ionomer cement restorations, the prescription of 0.05% sodium fluoride mouthrinses (for daily use) should correctly be indicated. Moreover, the fluoridated solutions may possibly have an influence on microhardness at different depths, roughness, translucency, color and other characteristics of these restorative materials. In this way, the interaction of these mouthrinses solutions with the restorative materials must be well known, in order to prescribe them safely.

## Conclusions

Based on the results of the conducted study, it may be concluded that:

- All the fluoridated solutions tested in this study influenced the surface hardness of resin-modified glass ionomer cements;
- Fluorgard most affected the surface hardness of the tested materials;
- Fuji II LC presented the best results for all solutions and immersion times.

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