CONHEÇA O BBO

O QUE É O BBO

É uma certificação de excelência conquistada por ortodontistas que se submetem a uma comissão que avalia seu conhecimento e competência clínica. No Brasil, a Ortodontia foi a primeira especialidade da área de saúde a implantar esse processo permanente de avaliação e certificação profissional.

REQUISITOS PARA CERTIFICAÇÃO

1. Ser registrado como especialista junto ao Conselho Federal de Odontologia (CFO) e ao Conselho Regional de Odontologia (CRO).
2. Ser sócio da Associação Brasileira de Ortodontia e Ortopedia Facial (ABOR).
3. Ter sido aprovado nos exames das Fases I e II

PROCESSO DE CERTIFICAÇÃO

Envolve prova escrita (Fase I) e avaliação de casos tratados pelo ortodontista (Fase II). A prova escrita contempla aspectos mais importantes do tratamento ortodôntico, como diagnóstico, planejamento e técnicas ortodônticas. Sendo bem sucedido nesta prova, o profissional está habilitado a apresentar casos clínicos de diferentes maloclusões, tratados por ele (Fase II).

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Local: Rio de Janeiro/ RJ - Congresso ABOR
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Effect of time and environment conditions on mechanical-chemical-morphological properties of conventional glass ionomer cements

ABSTRACT: Introduction: The satisfactory performance of a restorative material when exposed to chemical challenge may be relevant for its clinical indication. **Objective:** This in vitro study investigated the effects of chemical challenge on compressive strength (CS), diametral tensile strength (DTS), surface roughness (R), surface hardness (H), fluoride release (F) and morphological characteristics (SEM) of popular restorative glass-ionomer cements (GICs). Methods: Maxxion R (MX) and Magic Glass (MG) were prepared according to the manufacturers' instructions. Cilindric-shaped (6 x 3 mm) and disc-shaped (4 x 2 mm) specimens were used for CS and for DTS, R, H, F and SEM tests, respectively. Specimens of each material were randomly distributed according to chemical challenge: Demineralization solution (DE; pH 4.3); Remineralization solution/artificial saliva (RE; pH 7.0). The specimens were individually immersed in 2 mL of the solutions, which were daily changed. After 15 days of storage, CS, DTS, R, H, F, and SEM analysis were performed. CS and DTS were evaluated using a universal testing machine; R was evaluated using a surface roughness-measuring instrument; and H, using

a Knoop microhardness tester. Data were analyzed by ANOVA and Tukey's tests (α=0.05). **Results:** Storage condition did not affect CS, DTS or R of both GICs. Before storage, MX showed H significantly higher than MG. However, after 15 days storage in both DE and RE solutions, there was no difference between materials. MG showed higher fluoride release than MX, in all evaluation periods and in both solutions. DE significantly reduced H and increased F of both materials. **Conclusions:** Chemical challenge promoted by DE increased degradation, reducing H and increasing F. RE did not affect the mechanical properties and surface characteristics of GICs. **KEYWORDS:** Glass ionomer cement. Compressive strength. Tensile strength. Hardness.

INTRODUCTION

Glass ionomer cements (GICs) have been used in dental practice and public programs for decades, being established as an important restorative material.[1-4] It has become the material of choice for Atraumatic Restorative Treatment (ART) due to its properties, such as fluoride release and uptake, chemical bonding to dental structure, anticariogenic properties, radiopacity, biocompatibility and chemical set reaction.[5-8] Conventional GICs are basically composed by a calcium fluoro-aluminosilicate glass powder and aqueous solution of an acrylic acid homo- or co-polymer.[2,9]

The GIC used in ART restorations have been called "condensable" or "highly viscous", been indicated to restore occlusal bearing areas. In this way, the GIC's ability to survive the occlusal force and the exposure to various chemical challenges in the oral environment is a requeriment for their long-term clinical performance.[10-12] In the oral cavity, chemical degradation may be caused by acid challenges of dental biofilm,[13,14] acid diet (soft drinks and juices)[10,15-17] and salivary enzymes.[13,18] These mechanisms may operate alone or in combination, promoting surface and subsurface degradation that may involve

the filler or matrix-filler interface, leading to increased softening and roughning which can decrease the long-term durability of the restorative material.[19-23] As a consequence, degraded surface of restorative dental materials could enable biofilm accumulation, which may result in superficial staining and onset of caries lesions, which would reduce even more the physic-mechanical properties of the material.[24] Therefore, GIC degradation in the oral cavity would be dependent on the media conditions.[25,26]

Thus, the satisfactory performance of a restorative material when exposed to chemical challenge may be relevant for GICs indication, specially when the material is intended to be used for restoring stress-bearing contact areas in high caries risk patients. When in contact with saliva, GICs may undergo a surface reaction that leads to the precipitation of calcium and phosphate ions at the outermost layer.[27] When exposed to acidic conditions, ions provinient from matriz are released, as part of a process of buffering the medium.[28] Althout a systematic review concluded that GIC provides long-lasting restorations for primary and permanent teeth,[29] it has been suggested that GICs' physic-mechanical properties may be altered overtime, possibly due to an acid-base reaction.[17,30-33] Therefore, the aim of this in vitro study was to evaluate the different chemicall challenges on conventional and high viscous GIC, that are very popular in Brazil, by means of compressive strength, diametral tensile strength, hardness, roughness and fluoride release measurements. The tested hypothesys is that the chemicall challenge promoted by demineralizing solution (DE) and demineralizing solution (RE) would negatively affect the mechanical properties and surface characteristics of GICs.

MATERIAL AND METHODS

Experimental design

The factors under analysis were: (1) Materials (Maxxion R = MX and Magic Glass = MG); and (2) Storage Condition (Control - No Storage = C; Demineralizing solution = DE; Remineralizing solution = RE) during 15 days. The brand names, types, compositions, manufacturers and batch numbers of the tested materias are presented in Table 1. Specimens of each material were prepared and randomly distributed by lottery method into storage conditions (n=5). The parameters under review were compressive strenght (CS), diametral tensile strength (DTS), surface roughness (R), surface hardness (H), and fluoride release (F) analysis. R and H analysis were perfomed before and after storage due to are no-destructive tests. Fluoride concentration in

both solutions was determined from 1st, 2nd, 5th, 8th, and 15th day. For all tests, DE and RE solutions were daily changed during the experimental period of 15 days. Also, the GIC's morphological characteristics were assessed by scanning electron microscopy (SEM) before and after storage.

Table 1: Brand, cement type, compositions, and manufactures of the materials used in the study.

MATERIAL	CEMENT TYPE	COMPOSITION	MANUFACTURER
Maxxion R	Conventional glass ionomer cement	Powder: Fluoraluminio silicate glass Liquid: polycarboxylic acid (45%), tartaric acid (10%), water.	Dentscare Ltda/ FGM Dental products Ltda. Joinvile-SC, Brazil
Magic Glass	Highly viscous glass ionomer cement	Powder: Fluoraluminio silicate glass, polycarboxylic acid and pigments. Liquid: Polyacrylic acid, tartaric acid and water.	Vigodent Dental Products Ltda. Rio de Janeiro-RJ, Brazil

Specimen Preparation

All specimens were prepared according to the manufacturers' specifications, at room temperature (23±1.0°C and 50±5% relative humidity, ISO #7489 specification). Thus, they were covered with a thin layer of petroleum jelly and stored for 24 h at 37°C and 100% humidity. Fittheen cilindric-shaped specimens (6 mm in height x 3 mm in diameter) were prepared for compressive strength test (CS) for each material (n=5). Disc-shaped specimens (4 mm in height x 2 mm in diameter) were prepared for: diametral tensile strength test (DTS) (15 specimens for each material, n=5) and for roughness (R), superficial hardness (H) and fluoride release (F) (15 specimens for each material, n=5); and morphology analysis (SEM) (n=3). The materials were inserted in plastic molds in single increment and pressed between polyester strip (Proben, Catanduva, Brazil) and glass plates, for 6 minutes until initial set. For specimens that were used to H, R and F analysis, a piece of paraffin dental floss was inserted into the cements during setting time to suspend in separate and different media while waiting for further testing (storage media). After, they were covered with a thin layer of petroleum jelly and stored for 24 h at 37°C and 100% humidity. Thus, specimens were polished with

600- and 1200-grit Al_2O_3 paper (Arotec, São Paulo, SP, Brazil) and then cloth polished with 1.0-μm diamond paste (Buheler, Lake Buff, IL, USA) before starting the test and storage. Afterward, all surfaces of the discs, except one surface (exposed area=28.26 mm^2) were protected with an acid-resistant nail polish (Colorama®, São Paulo, SP, Brazil).

Compressive strength test (CS)

After specimen preparation, specimens of each material were randomly distributed into 3 groups according to storage condition (n=5): 1) Control – No Storage; 2) DE solution (2,0 mM calcium, 2,0 mM phosphate and acetate buffer 75 mM, pH 4,3) during 15 days; 3) RE solution (artificial saliva composed of 1,5 mM calcium, 0,9 mM phosphate, KCl 150 mM and Tris [tris-(hydroxymethyl) aminomethane] buffer 20 mM, pH 7.0) during 15days. All specimens were individually immersed in 2 mL of each solution, under constant agitation at 120 rpm, 1.7 Hz (Cientec Model CT 165, Piracicaba, SP, Brazil) at controlled temperature of 25±1.0°C. The solutions were changed every 24 h.

For CS test, the specimens were placed in a vertical position with force incident on their long axis and loaded in compression at a crosshead speed of 1.0 mm/min in a Universal Testing Machine (Instron Model 4411, Instron Corp., Canton, Ma, USA) until fracture occurred. CS was calculated by following formula: $F/\varpi r^2$ where F is the load at fracture, r is the radius of the specimen, and ϖ = 3,14. The CS values (kgf/cm^2) were converted in MPa as follow: CS [MPa] = CS [Kgf/cm^2] x 0.09807.

Diametral Tensile Strength test (DTS)

For DTS analysis, same procedures used in CS test for specimen distribution and storage was performed. After, cylindrical specimens were horizontally positioned in a universal test machine (Instron Model 4411, Canton, Mass, USA) with 0.5 mm/min crosshead speed. DTS (kgf/cm^2) were calculated using the equation: DTS = 2F/3.14DT, where F was the failure load, D was the diameter, and T was the height of the specimen. DTS values were converted into MPa.

Surface Roughness Test (R)

Each disc specimen was gently dabbed dry with absorbent paper and the surface roughness was analyzed with a surface roughness-measuring instrument (Surfcorder SE 1700; Kosaka Laboratory Ltd, Tokyo, Japan) equipped with a diamond needle of 2-μm radius. In order to record roughness measurements, the needle was moved at a constant speed of 0.5 mm/s under a 0.7 mN load. The cut-off value was set at 0.25 mm to maximize

filtration of surface waviness. The surface roughness was characterized by the average roughness (Ra), which is the arithmetical average value of all absolute distances of the roughness profile from the centerline within the measuring length. Ra values for each specimen were taken across the diameter over a standard length of 0.25 mm. Three traces were recorded for each specimen at three different locations - parallel, perpendicular, and oblique to scan all specimen area. The average of these three traces was used as the score for each specimen (Ra-μm). The roughness test was performed at baseline (immediately after polishing procedures), and after 15 days of storage in DE and RE solutions.

Knoop Hardness Test (H)

Knoop hardness measurements were obtained on the exposed surface using a microhardness tester (HMV-2000, Shimadzu, Tokyo, Japão) with a Knoop diamond under a 50 g load for 10 s in the same specimens used for roughness test. Three indentations spaced 0.05 mm from each other were made in the central area of each specimen. The hardness test was performed at baseline (immediately after polishing procedures) and after 15 days of storage in DE and RE solutions.

Fluoride release analysis

After baseline analysis of R and H, all specimens were individually immersed in 2 mL of each solution: DE and RE, as described before. The solutionswere changed every 24 h. Triplicate aliquots of the solutions were mixed with TISAB III at ratio of 1:0.1 and analyzed using an ion-selective electrode (Orion 96-09; Orion Research Inc., Boston, MA, USA) and a digital ion-analyzer (Orion EA-940, Orion Research, Boston, MA, USA), which was previously calibrated with various standard solutions (0.03 to 10.0 μg F/mL). Fluoride release from each solution of each specimen after 1, 2, 5, 8, and 15 days of storage in DE and RE solutions were calculated considering the exposed area of the specimens (exposed area = 28.26 mm^2).

Scanning Electron Microscopy (SEM) Analysis

Three new speciemens and three representative specimens removed from RE and DE solutions of each material were dried, gold-sputter coated (Bal-Tec SCD 050 Sputer Coater, Bal-Tec; Balzers, Liechtenstein) and observed in SEM (JEOL JSM 5600LV, Tokyo, Japan) with accelerating voltage of 15 kV, working distance of 20 mm, and magnification of 80X. SEM photomicrographs were used to illustrate the morphology of the specimens of GICs.

Statiscal Analysis

Data were analyzed by Shapiro-Wilk's tests showed homogeneous variance and normal distribution. CS and DTS data were submitted to two-way ANOVA (Factor 1: Material – MX, MG; Factor 2: Storage Condition – C, DE, RE). R, H and F data were submitted to repeated-measures ANOVA as evaluation was performed in the same specimens in different periods, considering materials x storage media and the evaluation period. For all data, after ANOVA, Tukey's test was applied for pairwise comparisons. Statistical analysis was performed using Assistat Software (Assist, Version 7.7, Federal University of Campina Grande, Brazil)[34] and the significance level was set at 5%.

RESULTS

CS and DTS means and standard deviation of each material according storage condition are described in Table 2. There was no significant difference in CS or DTS neither between materials MX and MG, nor among storage condictions (RE and DE). The storage in DE or in RE solutions did not affect the CS and DTS of the tested GICs.

Surface Roughness (Ra) means and standard deviation of each material according storage solution and evaluation period are described in Table 3. There was no significant difference betwenn MX and MG in any condiction. Also, the storage in DE or in RE solutions didn't affect R of the tested GICs. Table 3 still shows the mean and standard deviation of the H of GICs according to storage solution and evaluation period. Considering baselines, MX shows H significantly higher than MG. However, after 15 days storage in both DE and RE soultions there is no difference between materials. Regarding the storage solution, only DE significantly reduced H of both materials. The storage in RE solution didn't affect H of both materials.

Table 4 shows the mean average and standart deviation of fluoride release analysis of the tested GICs, according to storage solution and evaluation period. According to Table 5, MG shows highr fluoride release than MX, in all evaluation periods and in both solutions (DE and RE). In general terms, the fluoride release is higher in DE solution then in RE solution. For MG, there is a higher fluoride release in DE than in RE on days 2, 5, 8 and 15. For MX, there is a higher fluoride release in DE than in RE on days 1 and 2. Also, it can be observed that the fluoride release tend to be highr in days 1 and 2in both solution. However, for MX, there is no statistical difference among all evaluation periods.

Table 2: Mean values (MPa) and standard deviations of compressive strength (CS) and diametral tensile strength (DTS) of the tested GICs, according to storage conditionn.

MEIO DE ARMAZENAMENTO	COMPRESSIVE STRENGTH (MPA) *		DIAMETRAL TENSILE STRENGTH (MPA)**	
	Maxxion R	Magic Glass	Maxxion R	Magic Glass
Control	47,47 (26,16)^{aA}	60,18 (13,63)^{aA}	15,22 (4,80)^{aA}	13,97 (2,09)^{aA}
DE	55,83 (24,54)^{aA}	72,81 (21,50)^{aA}	16,14 (3,62)^{aA}	12,72 (4,46)^{aA}
RE	64,45 (30,93)^{aA}	57,30 (24,79)^{aA}	17,18 (5,16)^{aA}	19,00 (4,36)^{aA}

Different lowercase letters in column and uppercase letters in line differ significantly (p<0,05). * For CS, Minimal significant difference (MSD) in line = 31.57; MDS in column = 38.17. ** For DTS, MSD in line = 5.49; MDS in column = 6.64

Table 3: Mean values (µm) and standard deviations of surface roughness (R) of the tested GICs, considering the Ra parameter and, surface hardness (H), expressed in KHN, according to storage solution and evaluation period.

CIV TESTED	SURFACE ROUGHNESS (µM)*				SURFACE HARDNESS (KHN)**			
	DE		RE		DE		RE	
	Baseline	15 days	*Baseline*	15 days	*Baseline*	15 days	*Baseline*	15 days
Maxxion R	0,57 (0,1)^{aA}	0,92 (0,2)^{aA}	0,89 (0,5)^{aA}	0,88 (0,7)^{aA}	40,74 (15,7)^{aA}	14,81 (8,6)^{aB}	42,2 (8,6)^{aA}	31,29 (3,5)^{aA}
Magic Glass	0,58 (0,2)^{aA}	0,79 (0,5)^{aA}	0,66 (0,2)^{aA}	0,70 (0,4)^{aA}	26,47 (6,2)^{bA}	11,12 (9,6)^{aB}	27,63 (6,8)^{bA}	28,71 (3,2)^{aA}

Different lowercase letters in column and uppercase letters in line differ significantly (p<0,05). * Minimal significant difference (MSD) in line = 0.5980; MDS in column =0.4504. * Minimal significant difference (MSD) in line = 12.54; MDS in column = 9.44

Table 4: Mean values (µg F-) and standard deviations of fluoride release, according to storage solution and evaluation period.

CIV	SOLUTION	1 DAY	2 DAYS	5 DAYS	8 DAYS	15 DAYS
Maxxion R	DE	4,96 (0,96)^{bB}	11,73 (0,99)^{bA}	2,29 (0,29)^{bBC}	1,91 (0,13)^{bC}	1,59 (0,27)^{abC}
	RE	1,64 (0,63)^{cA}	1,59 (0,33)^{dA}	0,15 (0,07)^{bA}	0,11 (0,09)^{bA}	0,15 (0,12)^{bA}
Magic Glass	DE	10,26 (3,66)^{aB}	17,71 (4,52)^{aA}	7,83 (1,02)^{aBC}	5,20 (1,30)^{aCD}	4,06 (0,86)^{aD}
	RE	7,79 (2,40)^{aA}	4,69 (1,51)^{cB}	0,28 (0,21)^{bC}	0,09 (0,03)^{bC}	0,09 (0,03)^{bC}

Different lowercase letters in column and uppercase letters in line differ significantly (p<0,05). Minimal significant difference (MSD) in line = 2.78.; MDS in column = 2.61.

SEM images of MX (A and B) and MG (C and D) presented in Figure 1. SEM analysis indicated irregular surface of Maxxion R with empty spaces (bubble caused by inclusion of air during the mix) and microstructure fractures when exposed to DE solution. The topography of both surfaces (Fig 1A and 1B) are similar, however, In Figure 1B, it is observed several fracture propagation. Magic Glass showed the same pattern of Maxxion R, the topography is similar in 1C and 1D, however in 1D, it can be observed more marcable fracture propagation.

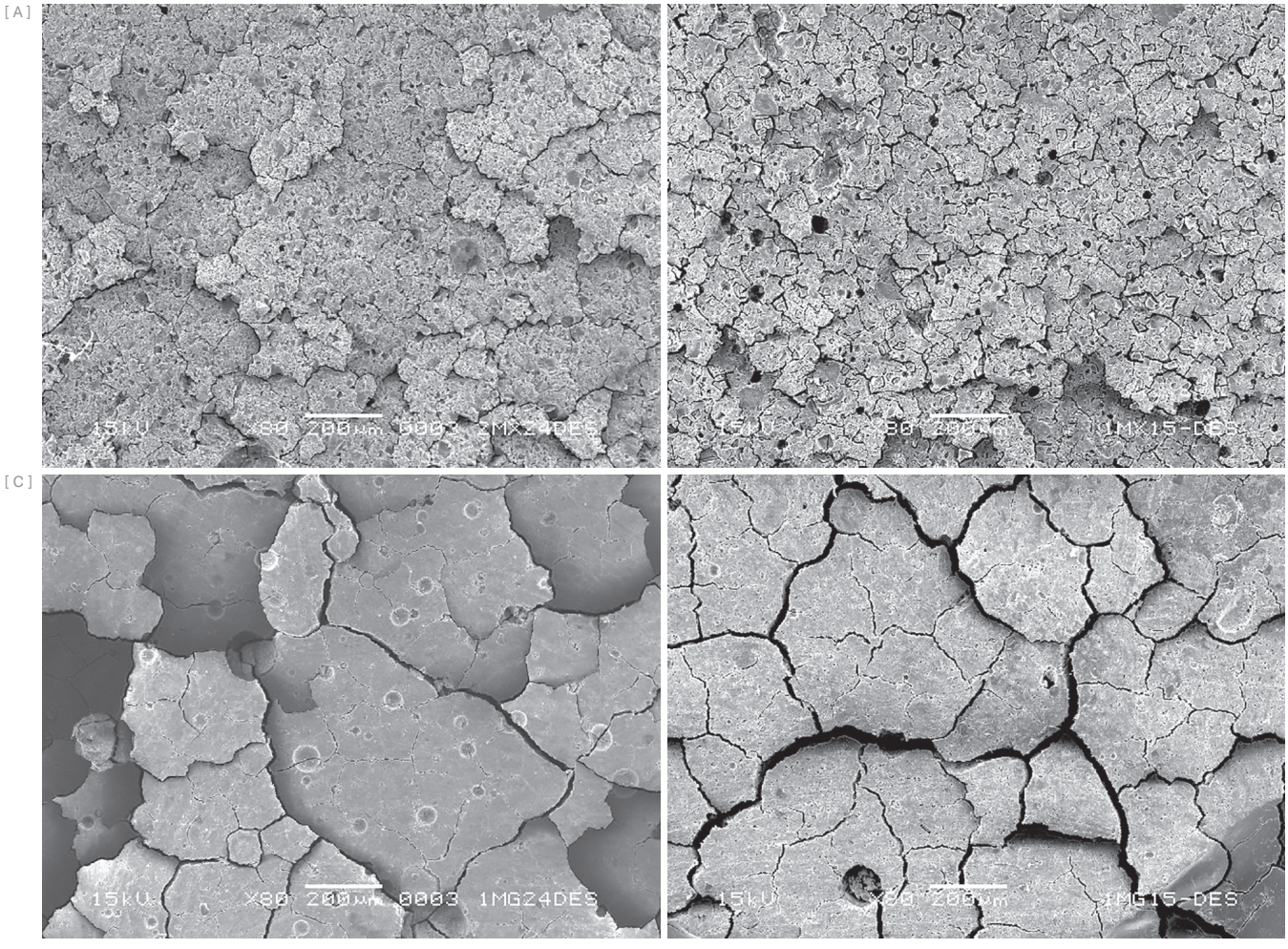

Figure 1: Photomicroghaph (80X) of Maxxion R after 1 day (**A**) and 15 days (**B**) and Magic Glass after 1 day (**C**) and 15 days (**D**) in DE solution.

DISCUSSION

Glass ionomer cement (GIC) consists of a calcium-aluminum-fluorosilicate glass powder that is combinated with polyacrylic acid or its copolymers. It has desirable properties to Dentistry, specially in the Pediatric Dentistry and at Atraumatic Restorative Treatment (ART) technique,[35] including adhesion to dental structure, biocompatibility, low coefficient of thermal expansion similar to those of tooth structure and anticariogenic properties because of fluoride release.[36] However, GIC exhibit some disadvantages such as inadequate mechanical properties and high solubility that may reduce longevity of GICs restorations in the oral cavity.[37,38] The materials selected for this study has an important space on Brazilian Dentistry, being applied in several prived practices and public health services due to the reduced cost in Brazilian market. In this way, it is very important to evaluate physical and mechanical properties as well to understand the degradation of this material when exposed to oral simulated solucions as DE and RE (artificial saliva).

Oral environment can be considered harmful to restaurative materials because the chemical-thermic-mechanical challenges that dental structures and fills are constantly exposed. The association of these factors is related directly to longevity/stability of fills such as dental structure preservation.[19]

Chemical degradation can be caused by acid challenges, including those produced by cariogenic biofilm,[39] acid diet[15,20,40,41] and salivary enzimes.[13,42] Diet is the most commum external source of acids related to biodegradation in the oral cavity. Consumption of acid drinks has been increased drastically in many countries, especially by children and adolescents.[43,44] The acids more frequently consumed are fosforic acid of the soft drinks, and citric acids of some fruit juices.[45,46]

Based on those factors is important to evaluate the development of GIC in front of acid challenges, to understand degradation mechanism. This study shows a broad view of GIC characteristics, including mechanical-chemical-morphological properties after the exposure to solutions that simulate oral environment, testing the hypothesys is that the chemicall challenge promoted by demineralizing solution (DE) and remineralizing solution (RE) would negatively affect the mechanical properties and surface characteristics of GICs.

Mechanical properties analyzed were compressive strength and diametral tensile strength. These data can show the britle characteristic of GICs, it was observed (Table 2) that compressive strengths were substancially higher than diametral tensile strengths, which agree with Xie et al.[47] The reason of this occurence is the fracture propagation that is favor when material is exposure to tensile strength effort.[47]

Considering the materials studied, mechanical strength of both Maxxion R and Magic Glass was similar, regardless the storage condiction. In this way, the chemical degradation didn't affect the mechanical properties, indicating that there is a mechanical stability of the GICs.[48] However, the hybrid imbalance can cause instability, generated for example by the lack of material surface protection during initial of its setting reaction. Xie et al.[47] found higher values of strength than those observed in this study. Anyway, materials that were used in this study are from differents commercial brand. In addition, specimens of Xie et al.[47] study were bigger that these samples, but the main point in this study is the chemical degradation of materials.

In this study, it was observed a significant decrease of hardness of both GIC when exposed to DE solution for 15 days, what can be attributed to the low pH of DE solution. According to Crip et al.[49], corrosion of materials in the oral environment is an addition of effects of 2 processes: dissolution and disintegration. Dissolution can be understood by quantity of leached material to solution, corresponding to soluble products in water; while disintegration is the quantity of material decomposition in insoluble products. In acidic conditions, there is higher disintegration

of GIC,[49] with release of degradation products as, SiO_2, Al^{3+}, Na^{+} and F^{-}. The release of these degradation products has been pointed out as the cause of increasing roughness[20,21,50] and decreasing superficial hardness.[20,39,51] In this study, however, there was no effect of the storage solution on roughness. It can be explained by the absence of mechanical abrasion in the degraded specimens. In this way, the soft layer on degraded surface is not removed and the roughness of the surface is not affected.

Roughness of restorative materials determines index of retention of microorganisms. Increase of superficial roughness lead to faster colonization and maturation of biofilm, so it increases the risk of development of caries and periodontal disease.[24] Furthermore, rough surface can increase the susceptibility to staining and corrosion of restorative materials[52] or produce more wear of tooth or antagonist fill.[53,54] This property can to be affected by characteristics of the matrix, the proportion of the size of the inorganic glass particles, the exposure of these inorganic particles and the formation of air bubbles during preparation of the material.[55] The roughness values were similar to other study.[56] When solution has neutral pH, as RE solution, less surface degradation is expected. This study confirms this hypothesis. There was no significant increase of roughness, or decrease in hardness or CS or DTS over the time for both GIC.

Fluoride release was directly affected by storage solution and time. Both materials had more fluoride release in acid solution (DE solution), corroborating with Karantakis et al.[57] and Muller et al.[58] This phenomenon is related with de disintegration of the material, once dissolution of GICs increases in low pH.[48] Aditionally, according to Asmussen and Peutzfeldt[59] water difusion inside the material creates hydrogen ions that attack fluorosilicate glass particles, releasing fluoride. In this way, fluoride release from MG is significantly higher than from MX, since it is more soluble, it has a slower prey reaction and is more porous.[60] This fact may also explain its less hardness. However, the fluoride release pattern was similar for both GICs, showing a high initial release, specially at the first two days, thus it decreases gradationally until get a plateau at 5º day. Fluoride release after 5 days in RE solution was pratically null, while there was small but constantly fluoride release in the DE solution, as observed in Table 5.

Considering the results of this study, the tested hypothesys is that the chemicall challenge promoted by demineralizing solution (DE) and demineralizing solution (RE) would negatively affect the mechanical properties and surface characteristics of GICs was only partially acceped. As RE solution had no effect on mechanical properties of GICs and DE solution caused a decrease in hardness, but haven´t affected CS, DTS and R of GICs.

Although most properties of the tested GICs was similar, Magic Glass showed reduced hardness and higher fluoride release, what might be related to a tendency to higher susceptibily to degradation over the time than Maxxion R, especially in the acidic conditions.

CONCLUSION

The chemical challenge promoted by the acidic solution increase degradation, reducing surface hardness and increasing fluoride release. While the chemical challenge promoted by the neutral solution, simulating artificial saliva not affects the mechanical properties and surface characteristics of GICs.

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