

Original Article

Assessment of Glass Ionomer Cements (GIC) Restorations after Acidic Erosive Challenges: An in vitro Study

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Abstract

Objective: To analyze the marginal adaptation of two different Glass Ionomer Cements (GIC) after erosive challenges. **Material and Methods:** Sixty sound extracted primary canines were selected and class V cavities were made. Teeth were allocated into 6 groups according to restorative material: 1) high-viscosity GIC (KetacTMMolar Easymix) and 2) resin-modified GIC with nanoparticles (KetacTMN100), low pH beverage erosive challenge (Orange juice and Coca-Cola) or distilled water as control. Thereafter the sample was restored and subjected to thermocycling. The sample was immersed for a 10-days period for the erosive simulation and then embedded in methylene blue solution during 4 hours. Finally teeth were sectioned for further analysis. Marginal adaptation test was performed by two trained examiners using the Salama et al. criteria. Descriptive and Kruskal-Wallis test ($\alpha=5\%$) were used to analyze the data. **Results:** The groups treated with KetacTMMolar EasyMix were similar in terms of marginal sealing ability when submitted to Orange juice and Coca-Cola but significantly worse than water. For samples restored with the KetacTMN100 the worst results were found in the Coca-Cola group. **Conclusion:** Erosive challenges with acidic drinks affected the marginal adaptation of the tested GIC.

Keywords: Dental marginal adaptation; Glass Ionomer Cements (GIC); Tooth erosion.

Introduction

Dental caries and dental erosion are diseases that affect not only less-favored populations but also those from developed countries [1-3]. Sometimes the severity of those diseases requires restorative treatment in order to bring back functionality and esthetic [4,5]. Glass Ionomer Cements (GIC) are elective materials for restorations in such kind of dental problems because they have excellent properties such as fluoride release and uptake and biocompatibility [6-8]. Thanks to its sustained benefits is now used in daily clinical settings and all kind of populations [9].

The change of habits and lifestyles in the population increased the variety and quantity of acid beverages/foods consumption, promoting tooth and oral materials wear which raises the possibility of developing dental erosion and associated discomfort [10-12].

GIC restorations are unavoidably in contact with the oral environment and exposed to intrinsic fluids and beverages/foods from diet. Dietary habits with rich acid contents possibly result in restoration fail and gaps formation between the tooth and the restoration.¹³ However there is weak evidence and no studies about the margin sealing ability of GIC submitted to erosive challenges have been conducted.

This study was developed to analyze the behavior of two different GIC, evaluated by marginal adaptation test, after subjecting them to erosive challenges that possibly result in restoration defect.

Material and Methods

Prior to the beginning, the Committee for Ethics in Research of University Cruzeiro do Sul, São Paulo, Brazil approved the study (protocol 146 / 2008).

Sample

Sixty sound extracted primary upper and lower canines were selected from the Human Teeth Bank of the Dental Faculty, University of São Paulo, Brazil and were stored in tap water until the beginning of the procedures to promote rehydration.

Cavitation Procedure and Groups

Class V cavities (2 x 3 x 1,5 mm. depth) were made by one trained operator in the middle third of the buccal surface with margins only in the enamel with a diamond bur (#1090 KG Sorensen, Barueri, SP, Brazil) and high-speed handpiece with water spray. Then, the sample was randomly allocated into 6 possible groups according to restorative material, low pH beverage challenge or distilled water where the sample was stored as follows:

- Group I: Ketac™Molar Easymix (3M ESPE) – stored in distilled water, with thermocycling (n=10).
- Group II: Ketac™Molar Easymix (3M ESPE) – stored in orange juice (Del Valle, The Coca-Cola company) with thermocycling (n=10).

- Group III: KetacTMMolar Easymix (3M ESPE) – stored in Coca-Cola with thermocycling (n=10).
- Group IV: KetacTMN100 (3M ESPE) – stored in distilled water, with thermocycling (n=10).
- Group V: KetacTMN100 (3M ESPE) – stored in orange juice (Del Valle, The Coca-Cola company) with thermocycling (n=10).
- Group VI: KetacTMN100 (3M ESPE) – stored in Coca-Cola with thermocycling (n=10).

Restorative Procedures

The materials' compositions as well as the application's instructions are described in Table 1. All test cavities were restored following the indications recommended by the manufacturer. The pre-treatment in KetacTMMolar Easymix groups was made with polyacrylic acid applied with cotton ball for 10 seconds. Afterwards all cavities were washed and dried with cotton balls. For KetacTMN100 groups the primer was applied for 15 seconds and then light cured for 10 seconds.

Table 1. Material composition and application used in this study.

| Material | Composition | Application |
|---|---|---|
| Ketac TM Molar Easymix (3M ESPE, Seefeld, Germany) | Ketac TM Conditioner: Polyacrylic acid (25%) Powder: Calcium aluminum-lanthanum-fluorosilicate glass, acrylic acid-maleic acid copolymer, pigments Liquid: Water, acrylic acid-maleic acid copolymer, tartaric acid | Apply Ketac Conditioner (10 s); rinse with copious amount of water; gently air-dry (5 s); leaving a moist surface. Dose 1 drop of liquid and one powder scoop, mix up to 30 seconds; apply to enamel and dentin surfaces. |
| Ketac TM N100 (3M ESPE, Seefeld, Germany) | Primer: water (40-50%); HEMA (35-45%); acrylic/itaconic acid copolymer (10-15%); photo-initiators. Ketac TM N100: De-ionized water, HEMA, vitrebond copolymer \ methacrylate modified polyalkenoic acid, fluoraluminosilicate glass, nanomers and nanoclusters. | Dispense and apply the nano-ionomer primer during 15 s; air-dry for 10 s (shiny surface); light cure (10 s); Dispense 2 clicks of the Ketac N100; mix for 20 s (uniform color); apply incrementally (≤ 2 mm); light-cure each layer for 20 s. |

After adequate mixing, the GIC was placed into the cavities with spatula 1 (Dental MFG. Co. USA). Subsequently a finger pressure was made with the glove dipped in petroleum jelly on the restored cavities with KetacTMMolar Easymix. All excesses were removed with Hollenback. For the other groups, after ionomer placing, light curing was performed (LED Curing Light 3M Unitek). Petroleum jelly (Farmax) was applied for all groups with a thin brush over the restorations for avoiding the materials' synerisis and imbibition during the first 24 hours. Finally all teeth were maintained in tap water at 37°C for 24 hours.

Thermocycling

After the restorative procedures all the specimens were taken to a thermal cycling machine (Nova Ética Ind. Com. e Serviços, 521-4D) from the Department of Operative Dentistry, Dental

Faculty, University of São Paulo; and received 1-minute baths, with 15 seconds of dwell time at 5°C and 55°C for 700 cycles.

Erosive Challenge Simulation

Two beverages commonly tested in erosion studies were used [14]: Artificial orange juice (Del Valle, The Coca-Cola Company) with a pH 3.6; and Coca-Cola classic soda with a pH of 3.5, measured after opening the bottle and previously to the immersion of teeth. Distilled water was taken as a control.

After thermocycling teeth were immersed for a period of 10 days at 37°C in the acid beverages (20ml) described above to simulate the erosive effect [15]. Beverages were replaced every day during the experiment and the pH was measured periodically before teeth immersion and after 24 hours.

Infiltration and Sectioning

Two layers of red nail varnish were applied to all the surface of the teeth excepting the restored area and 1mm around it.

After the 10-days erosive challenge, teeth were washed with water and then dried with paper towels. Thereafter all of them were embedded in methylene blue solution 0.5%, pH 7.0, during 4 hours. This procedure allowed tracing gaps between GIC and tooth structure. Finally after these 4 hours the specimens were rinsed with water for 1 minute and left in paper towels for 2 hours. Teeth were then sectioned (Labcut, Extec) through the middle of the restoration and the half with more infiltration was chosen for analysis.

Evaluation

Macro photographs of the chosen samples were taken (16X of magnification, *Canon DS126151 EOS Digital Rebel XTi*, *Canon Macro Lens EF 100mm 1:2.8 USM* standardized in *AF 0.31m - Close-up One Shot* with Flash *Canon SD 770 IS Digital Elph*) and the evaluation was performed by two calibrated examiners using a scoring scale described by Salama et al. [16]: 0 = Without penetration; 1 = Infiltration up to the middle of the incisal or cervical wall; 2 = Infiltration all over the incisal or cervical wall; 3 = Infiltration reaching the axial wall and 4 = Infiltration in the direction of the pulp. The evaluations were performed again after one week interval.

Statistical Analysis

Inter and intra-examiner reliability was calculated using Weighted Kappa test. The non-parametric test Kruskal-Wallis was used with $\alpha=5\%$. All statistical analysis was done with the SPSS 21.01 (SPSS Inc, Chicago, USA).

Results

Sixty sections were included for analysis. Inter and intra-examiner values (weighted Kappa) for specimens' evaluation were 0.84 and 0.87 respectively.

The pH values and variation for distilled water were 7.4 in the beginning and 7.6 measured after 24 hours; orange juice 3.6 and 3.7; and for Coca-Cola 3.5 and 3.7 respectively.

KetacTMN100 + Coca-Cola showed the highest proportion of score 4, indicating the worst marginal adaptation. On the other hand KetacTMN100 + water showed the lowest values (0 and 1) for the same condition compared to orange juice and Coca-Cola ($p < 0.0001$). Additionally, the same material showed a significantly better performance when submitted to the orange juice erosive challenge compared to the Coca-Cola group ($p < 0.0001$) (Table 2).

Table 2. Marginal adaptation scores among groups.

| Groups | Marginal Adaptation Scores | | | | | Dif.* |
|------------------------|----------------------------|---|---|---|---|-------|
| | 0 | 1 | 2 | 3 | 4 | |
| N100 + Water | 6 | 4 | 0 | 0 | 0 | a |
| N100 + Orange juice | 0 | 3 | 2 | 3 | 2 | b |
| N100 + Coca-Cola | 0 | 1 | 1 | 1 | 7 | c |
| Easymix + Water | 5 | 3 | 2 | 0 | 0 | a |
| Easymix + Orange juice | 1 | 4 | 1 | 3 | 1 | b |
| Easymix + Coca-Cola | 0 | 2 | 2 | 3 | 3 | b,c |

* Different letters indicate a statistically significant difference among groups ($p < 0.0001$). Test K-Wallis.

The groups restored with KetacTMMolar Easymix + orange juice and Coca-Cola were similar in terms of margin sealing ability but showed a significant difference when compared to water ($p < 0.0001$). When differences among all groups were explored, the control groups both Ketac N100 and Ketac Molar Easymix presented the best performance. Moreover, the two GIC + Coca-Cola did not show differences in marginal adaptation values, but only the Ketac N100 + Coca-Cola was statistically worse when compared with the orange juice groups (Table 2).

Discussion

The GIC materials are wide used in contemporary dentistry because of its chemical, physical and clinical properties, which includes adhesion to the tooth structure, coefficient linear thermal expansion similar to tooth and fluoride release and uptake, among others [3,6,17]. The adhesion to tooth structure contributes to the marginal adaptation and aiming to maintain the longevity of the restoration [18].

One of the most important properties, which determine the durability of the marginal sealing in such a kind of materials in the oral cavity, is the resistance to dissolution or disintegration. This could take place due to acidic conditions occurring when foods and drinks are ingested [19].

Population lifestyle has been changing for decades, and the current consumption of acidic foods and beverages is extremely high, mainly in children and adolescents [9,20]. There is also a fact that acidic drinks can dissolve and disintegrate restorative materials, this study worked with the

hypothesis that the acidic beverages could affect the tooth-restoration interface jeopardizing the marginal adaptation.

Although the main focus in microleakage studies has been the impact on the pulp, there are also some other considerations to take into account. The lack of marginal adaptation of various substances in and around the restoration and tooth structure could affect the material properties resulting in secondary caries and/or dentin hypersensitivity [21].

Current restorative dentistry researches using GIC assess different ways to avoid the gaps in the tooth-restorations interface, which, according to some authors, it is still not well considered [22,23]. Results from this study indicate a better behavior in terms of microleakage scores for the water group in both GIC tested materials but the same trend was not seen for the orange juice and Coca-Cola groups, possibly due to the low pH in this beverages.

Although some GIC restorations failed in obtaining a marginal adaptation at tooth-restorations interface in this "in-vitro" setting, the material may have good performance in clinical situations due to fluoride release and uptake as well as the ability of delaying or preventing the development of secondary caries lesions [7]. Notwithstanding clinical studies must be performed to assess this condition in vivo.

It is well known that thermocycling is commonly used in materials researches to simulate the oral environment. However, it is widely discussed its effectiveness when trying to imitate buccal conditions and the obtained results are difficult to extrapolate to real conditions [24]. Anyhow, the use of thermocycling brings the advantage of representing in vitro, the material aging and material degradation phenomenon that occurs in real conditions after a certain period of time [25]. Besides, this kind of studies brings benefits such as the knowledge of some parameters like erosion time, potentially erosive agents and pH values [26]. Actually in this study the pH values were periodically measured before and after 24 hours of the specimens' immersion and there were no variations in accordance with some authors [27].

Nomoto and McCabe [28] tested restored samples with acid erosion showing profound loss of material, which probably occurred because of the not adhesion of the acrylic to the walls of the cavities allowing the dissolution and penetration. Despite GIC exhibit good adhesion to the tooth tissue, preventing penetration of acidic beverages, the differences found in this study could explain the negative influence of a diet rich in acids and the success of restorations.

The resin modified GIC have improved the mechanic and aesthetics properties due to the presence of nanoparticles in their composition, which could allow a lower surface wear [11]. On the other hand the high-viscosity GIC presents a higher color stability [29]. However, in this study both materials presented similar behavior in terms of marginal adaptation. Although the erosive challenges affect GIC performance [11], it is well known that the presence of microleakage does not affect the development of caries due to its properties maintaining good levels of fluoride possibly decreasing its progression [30].

The professional must inquire about the patient's diet, eating habits and hygiene in order to predict or estimate the material's behavior and judge the appropriateness of their application besides patient's counseling in reducing the consumption of acidic beverages [31].

Conclusion

Erosive challenges with acidic beverages as orange juice and Coca-Cola could affect the marginal adaptation of the tested GIC.

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