The ART of GIC proximal restorations in primary teeth

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Chapter 4

Flowable GIC as a liner: improving marginal adaptation of ART restorations

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Abstract

Aim: The present study aims to evaluate the in vitro microleakage of two-layer GIC proximal restorations in primary molars.

Methods: Forty primary molars received proximal cavity preparations and were randomly divided in two groups. G1 was restored with a regular powder/liquid ratio GIC. G2 firstly received a flowable layer of GIC and secondly a regular GIC layer. After 24 hours water storage (37ºC), the teeth were made impermeable with the exception of the restoration area and 1 mm of their surroundings, immersed in 0.5% methylene blue solution (4 h), rinsed and sectioned mesio-distally. One side was polished with and analyzed under light microscope. Replicates from the other side were observed under SEM. Microleakage evaluation was carried out by 3 evaluators.

Results: The data analysis (Mann-Whitney test) showed a significant ($p<0.01$) better result for G2. Regarding the SEM evaluation, irregularities were observed in G1 at the tooth/GIC interface. For G2, it was not possible to observe any displacement of the GIC in relation to the tooth structure, which confirmed better adaptation as seen in the microleakage test.

Conclusion: the insertion of a flowable GIC layer in proximal cavities before the insertion of a regular GIC layer improves the material adaptation to the tooth.

Introduction

Contemporary treatments in Pediatric Dentistry search for restorative techniques with maximum prevention and minimum intervention. The Atraumatic Restorative Treatment (ART) is one of the existing treatment approaches that fits with this philosophy. In two recent meta-analyses, Frencken *et al*. (1) and van 't Hof *et al*. (2) found no difference in survival rate of glass ionomer (ART) compared to amalgam in single surface restorations. These findings contribute to scientific evidence for the ART approach and reinforce its indication (3).

The material of choice for ART is high viscous glass ionomer cement (GIC) (4) due to its well-known properties, i.e. bonding to enamel and dentin, fluoride release and uptake, biocompatibility and chemical set reaction. However, this material presents a viscous consistency, what makes it a cement with complex manipulation and insertion characteristics.

The clinical behavior of GIC in proximal-ART restorations is far from ideal compared to single surface restorations (2, 5-8). An important factor that may contribute to the proximal-ART restoration failure is the high viscosity of the material, which leads to a difficult insertion or incorrect adaptation to the tooth surface which turns to cervical gaps (9-11). The material's insertion must be done when the consistency is not too thick and it is still shiny (12, 13), indicating that remaining polyacrilic ions are available for chemical bonding to the tooth structure.

It is unknown if the use of a thin layer of GIC with a more flowable consistency before the insertion of a high viscous consistency layer can reduce these adverse effects. The aim of this study is to evaluate the in vitro microleakage of two-layer GIC proximal restorations.

Materials and Methods

This study was started after approval of the Ethical Committee of the School of Dentistry (University of São Paulo). All the restoration were performed by one operator which was not participating in the evaluation. Forty non-carious, intact primary molars, obtained from the Human Tooth Bank at the University of São Paulo were cleaned with pumice and a Robinson® brush in low-speed hand piece and washed with water. Subsequently, the cavities were prepared with a diamond bur number 3101 (KG Sorensen, São Paulo, Brazil) in a water-cooled high-speed hand piece. Dimensions of the cavities were 3 mm wide (bucco-lingual direction), 2 mm length (mesio-distal direction), and 3 mm deep. For standardization purposes a millimeter ruler and a K file was used. Specimens were randomly assigned in two groups (n=20).

The control group: the cavities received pre-treatment with Ketac Molar™ Easymix (3M/ESPE, Seefeld, Germany) liquid diluted (10s); then specimens were water rinsed and dried with cotton pellets. Metal bands were placed and the restorations were made in accordance with the established technique quoted in the book of Frencken & Holmgren (4). GIC was mixed according to manufacturer's instructions: 1 powder scoop (142 mg – measure with precision balance Ohaus Adventurer®) and 1 liquid drop (1:1); hand mixed until a homogeneous consistency was achieved. The GIC was applied in small increments by being pushed into the corners of the cavity. After overfilling the cavity, the GIC was firmly pressed into the cavity with a gloved index finger with petroleum jelly (14). After the initial setting time (3 minutes) the restoration was finished with a carving instrument.

Two-layer group: the cavities received the same pre-treatment in as control group. Metal bands were placed and the restorations were made using two different GIC layers. In the first layer the GIC was hand-mixed with half a portion of powder (71 mg) and one liquid drop (0.5:1). A flowable consistency mix was achieved. The first layer was inserted with conventional application instrument, and in order to fill the cavity, the second layer was hand-mixed according to the manufacturer's instructions (powder/liquid 1:1) and applied before the hardening of the first layer. After overfilling the cavity, the GIC was firmly pressed into the cavity with a gloved index finger with petroleum jelly (14). After the initial setting time (3 minutes) the restoration was finished with a carving instrument.

After 6 minutes petroleum jelly was applied on the surface of all restorations to avoid water uptake and loss. The specimens were stored in distilled water at 37ºC for 24 hours and later were made impermeable using cyanoacrilate ester (Super Bonder, Henkel Loctite Products, Rocky Hill, CT, USA) in the apical region to prevent dye penetration. Two nail polish layers (Impala, Guarulhos, SP, Brazil) were applied on all tooth surfaces, with the exception of the restoration area and a 1 mm margin around the entire restoration.

The specimens were immersed in 0,5% methylene blue solution, pH 7.2, (Fórmula & Ação Farmácia – São Paulo, SP, Brazil) for 4 hours. Subsequently, they were rinsed in tap water for one minute, and left on absorbent paper for two hours.

The specimens were sectioned once in mesio-distal direction using a cleaver. One side was polished with a 1200 grid silicon carbide paper (Buehler Ltd, Lake Bluf, IL, USA) to be analyzed under light microscope (Olympus SZ-PT, Tokyo, Japan). Replica impressions were taken of the other side, using Express (3M/ESPE, Seelfeld, Germany) as the impression material. Replicas were made with epoxy resin (Epo-thin® Buehler Ltd, Lake Bluf, IL, USA) and prepared for viewing under scanning electron microscope - SEM (LEO 440i, Cambridge, UK).

The SEM evaluation was made with 50x, 200x and 1000x magnifications, in order to observe the interface between tooth structure and GIC. Ten unidentified specimens of each group were analyzed in random order to observe interface differences, adaptation, voids and cracks.

Three evaluators, previously trained and blind in relation to groups, examined independently a hard copy of the images taken using a microscope (Olympus SZ-PT, Tokyo, Japan) with 15x magnification. The examiners had attributed values to the penetration of the tracer agent, according to a scale proposed by Salama *et al*. (9) (Figure 1).

The data were analyzed using a GMC software program (GMC version 7.5, Bauru, SP, Brazil). The Mann-Whitney test was performed to determine statistically significant differences between the groups, based on $p \leq 0.05$. The inter examiners agreement was calculated by means of a Cohen's Kappa test.

Results

The inter examiner agreement, calculated with Cohen's Kappa test ranged from 0.78 to 0.89. The data analysis showed a statistical significant difference between the two groups ($p \leq 0.01$) with better results for the two-layer group. Figure 2 shows the results in percentage for each group.

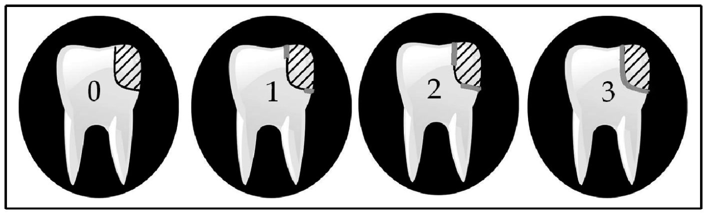

Figure 1: Scale to attribute values to the penetration of the tracer agent [Salama *et al*. (9)]. 0: no penetration of the tracer agent; 1: penetration of the tracer agent in the superficial interface of the incisal or gingival face; 2: penetration of the tracer agent in all extension of the incisal or gingival face, without achieving the axial wall; 3: penetration of the tracer agent in all extension of the incisal or gingival face including the axial wall.

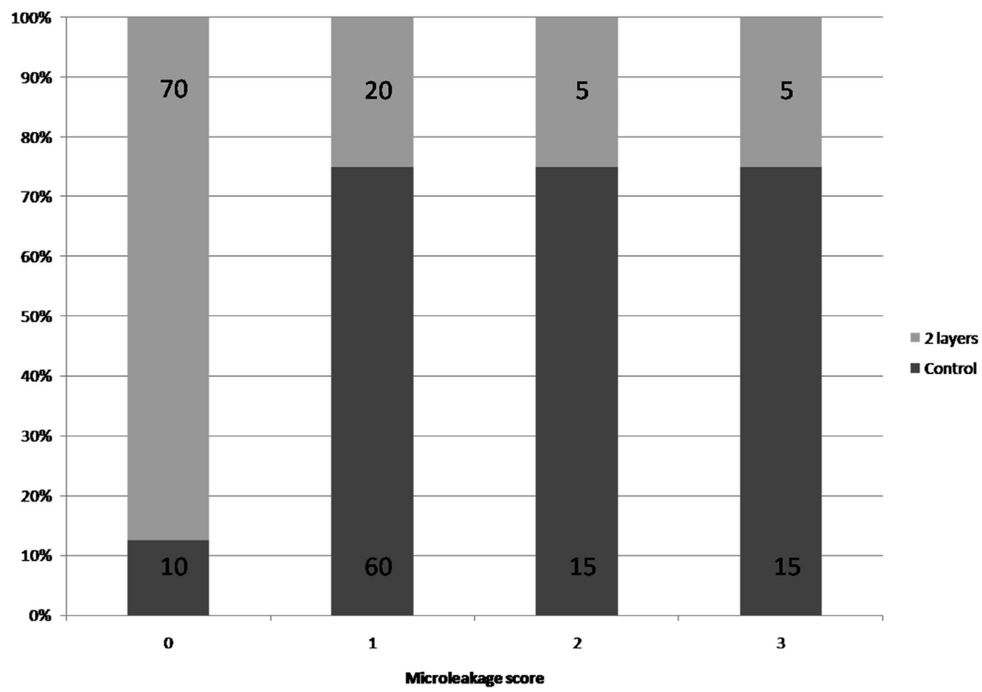

Figure 2: Results in percentage for each group and microleakage score. The number shown in the bars represent the number of cases per group with each score.

Regarding the SEM evaluation, it was possible to observe some irregularities in the interface between GIC at the tooth structure for the control group, including some gaps (Figure 3) evidencing the absence of an intimate contact between the GIC and the tooth. For the two-layer group, it was not possible to observe any failure or gap between the GIC and the to the tooth structure, demonstrating a better adaptation (Figure 4).

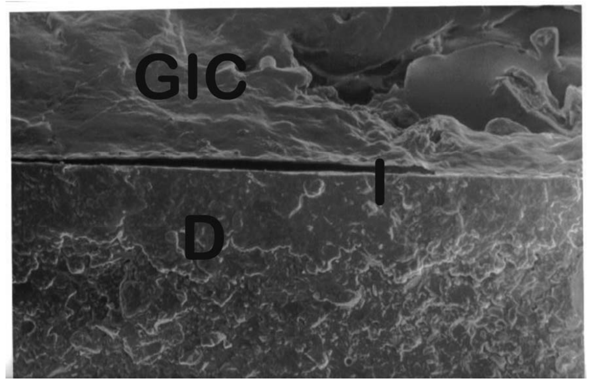

Figure 3: Control Group Scanning Eletronic Microscope (1000x). D – dentin; I – interface tooth/restoration; GIC - glass-ionomer cement 116 x 75 mm.

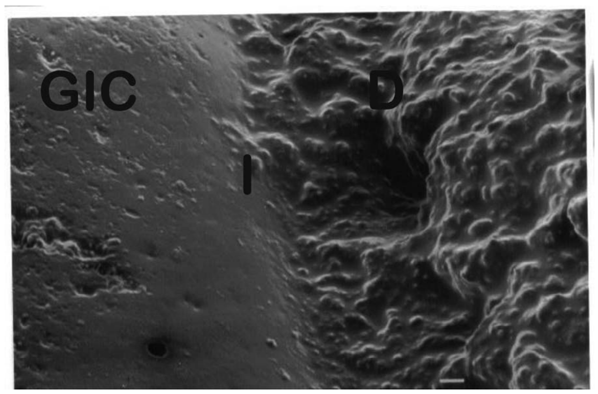

Figure 4: Two-layer group Scanning Eletronic Microscope (1000x). D – dentin; I – interface tooth/restoration; GIC – glass-ionomer cement 182 x 131 mm.

Discussion

The restorations made with the flowable GIC as a liner seem to improve the cavity walls adaptation in proximal cavities of primary teeth, in comparison with the traditional ART restorative method purposed by Frencken & Holmgren (4). The restorations made with the flowable GIC as a liner showed less microleakage (p<0.01) and no voids at the tooth/restoration interface.

Despite the fact that the mechanism of GIC bonding to the tooth structure is not completely clear, it is known that chemical adhesion is achieved by an interaction between the carboxylic groups from the polyacids and the hidroxiapatite as the former displace phosphate and calcium ions from the latter (12, 15). The lower powder-liquid ratio used for the flowable layer has important characteristics related to the adhesion to tooth structures. The higher polyacrilic acid available can be responsible for a higher number of cross-links and a better wettability. These facts can explain the less microleakage and no voids in the two-layer group.

The adhesion principles suggest that the most fluid materials penetrate better in the substrate, favoring the micromechanical adhesion (16). A better adhesion also contributes to an increased resistance to microleakage (17). The GIC presents a chemical and a micromechanical adhesion and both mechanisms are enhanced by the flowable layer.

Cracks were not observed in the two-layer group, neither at the tooth/restoration interface, nor between the first flowable-GIC layer and the second conventional-GIC layer. Apparently, the presence of a flowable-GIC layer in the dental cavity allows better adaptation of the whole material in the cavity.

It is important to emphasize that the SEM was carried out in acrylic resin replicas. These replicas were confectioned due to the fact that the previous dehydration needed for the SEM observation may lead to cracks in the material, as GIC is a water-based material. On the other hand, as the observations were made in resin replicas, which resemble the teeth surface with great quality, it is possible to conclude that the images are reliable. This gives us strong confidence on the conclusion regarding the presence of crack and air bubbles in this study.

The sample size of this study was not so big in order to make possible the SEM evaluation of all the replicas. Increasing the sample number could bring more solid conclusions. Additional in vitro studies should be conducted to clarify the strength properties of the two-layer GIC. It can be hypothesized there is no much differences between it and one-layer GIC. Not only because the two-layer GIC has the superficial layer with regular powder-liquid ratio but also because the flowable layer seems to present less voids which can improve the strength properties.

If the results found in the present in vitro study are confirmed with in vivo studies, a significant contribution to the reduction of failure proximal-ART restorations, widely registered in literature (10, 18-20), will be achieved.

It is also relevant to ponder whether the two-layer technique is better than the traditional GIC viscosity due to some of its disadvantages like the more material and time spent for it.

Aiming to improve the oral health of a significant part of the population that currently lacks access to conventional restorative dentistry treatment, additional research should be carried out in order to enhance the longevity of proximal restorations in primary teeth carried out by ART.

Conclusion

Based on the results achieved in the present study, it is possible to affirm that the insertion of a fluid GIC layer within proximal cavities before the insertion of a regular GIC layer improves the material adaptation to the teeth structures.

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