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Original Article

Microscopic evaluation of rotatory and handle caries removal on glass ionomer cement/dentin interface

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Aim: This study evaluated the interface between glass ionomer cement (GIC) and dentin using the conventional and atraumatic restorative treatment (ART) techniques for removal of decayed tissue. **Materials and Methods:** After preparation of the cavities by the conventional (Group I – GI) and ART (Group II – GII) techniques, the specimens were divided into 3 subgroups according to the GIC used (n=10). The conventional GIC KETAC FILL (3M/ESPE) was used in the groups GI-1 and GII-1, the conventional GIC VIDRION R (SS WHITE) in the groups GI-2 and GII-2, and the modified GIC FUJI II LC (GC Corporation) in the groups GI-3 and GII-3. For the microscopic analysis, the teeth were decalcified in a solution containing equal portions of 50% formic acid and 20% sodium citrate, dehydrated and submitted to paraffin baths. The samples were sectioned (6mm in thickness), stained by the Brown and Brenn method, and evaluated in a light microscope. **Results:** The microscopic analysis revealed interaction between the material and dentin structure only with the FUJI II LC. In addition, the behavior was superior for the conventional technique in comparison to the ART technique. **Conclusion:** It was concluded that the technique used for carious dentin removal does not seem to be determinant for the bonding of ionomeric materials to the dental structure, except for the resin-modified GIC in which the formed hybrid layer was higher using the conventional technique.

Keywords: Dental Atraumatic Restorative Treatment. Dental Caries. Glass Ionomer Cements.

Introduction

The Atraumatic Restorative Treatment (ART) technique is an alternative method recognized by the World Health Organization, which intends to provide dental treatment for destitute communities. This technique is indicated for treatment of carious lesions preserving the healthy dental structure. So, the ART can be applied in social programs with low technical financial funds[1-5].

The ART technique consists on coronal removal of the decayed tissue using only hand instruments and cavity restoration with glass ionomer cement. Among the properties of the glass ionomer cements, the adhesion to the dental structure (enamel and dentin) through ionic exchanges allows the formation of an acid-resistant adhesive layer between the ionomeric material and the tooth[6,7].

The majority of the studies concerning the ART technique performed longitudinal analysis of the restorations obtained by this method in comparison to the conventional techniques[1]. However, few studies evaluated the interaction between the ionomeric materials and the dental structure with different caries removal techniques. This evaluation is important to indicate a material and elucidate the reasons for the supremacy of this material in comparison to the others.

The mechanical properties of the glass ionomer bond interface to the tooth structure might be the main concern among researchers[8]. The conventional method for carious dentin removal using burs may generate better results since it eliminates a great quantity of infected and affected carious tissue[9]. When compared to the ART, the use of bur can easily eliminate the affected carious dentin, which provides better conditions for bonding procedures with glass ionomer[9]. On the other hand, some studies demonstrated a pause in the carious lesion progress and also a significant reduction in the number of bacteria when using the ART technique[4,10]. Hence, it has been observed the development of reparative dentin and preservation of pulp vitality[4].

Considering that the adhesion of glass ionomer to dentin is more critical than to enamel, this factor should be further evaluated by the researchers[6]. The electron microscopy is a common procedure to investigate the adhesive interface[11]. However, the polarized light microscopy may also represent an additional method for evaluation. The light microscopy is advantageous since several slices with 6µm in thickness can be obtained and, therefore, the total adhesive area can be evaluated as opposed to a small portion of the interface.

The development of materials with better mechanical properties increases the longevity of restorations in both deciduous and permanent teeth. These investigations may contribute to the use of the ART as a definitive restorative procedure not only in social programs but also in private practices[1,9].

The aim of this study was to evaluate the hypothesis that the interaction between glass ionomer materials and dentin is not affected by the mechanism of caries removal – burs or hand instruments.

Material and Methods

Sixty human carious molars with active shallow deep cavitated dentinal lesions (lesions radiographically extending less than the pulpal third of dentine[12]) were used in this study after approval by the Research Ethics Committee of FOA – UNESP (Protocol FOA 1538/2003). After the verification of extension of the carious lesion with radiographic examinations the teeth were randomly distributed among the groups to keep similar conditions for the tests. From the 60 teeth, 30 were prepared by the conventional technique (Group I - GI) and the remaining by the ART technique (Group II - GII).

The cavities in group GI were prepared with spherical diamond burs (1016 KG Sorensen, Barueri, SP, Brazil) in high speed under abundant water-air spray cooling. Selective removal to firm dentine was performed by using spherical burs compatible with the cavity size in low speed and without cooling. Selective removal to firm dentine was confirmed with the aid of an explorer to assess the consistency of the remaining dentin[13,14].

The cavities in group GII were prepared with hand cutting instruments and the selective removal to soft dentine was done with dentin excavators (Number 5, 11½ - DUFLEX SS White Artigos Dentários, Rio de Janeiro, RJ, Brazil) with circular movements until resistance for selective removal of carious tissue. It is worthwhile to note that hard dark or pigmented dentin remained in the cavity[4,5]. A sharp hand excavator was used to check the hardness of the remaining dentine[13,14].

Considering the adhesive properties of the restorative materials used in this study, no cavity contour or convenience forms were established, maintaining the enamel without dentin support.

After cavity preparation, the teeth were randomly divided into the subgroups according to the materials used (n=10): conventional glass ionomer cement KETAC-FILL (3M ESPE Dental Products, St Paul, MN, USA); conventional glass ionomer cement VIDRION R (SS WHITE, Rio de Janeiro, RJ, Brazil); and resin-modified glass ionomer cement FUJI II LC (GC CORPORATION, Tokyo, Japan) (Tables 1 and 2).

Table 1. Materials used and respective manufacturers and batches

Material	Manufacturer	Batch
KETAC FILL – PLUS – Powder (conventional glass ionomer cement)	3M ESPE	150374
KETAC FILL – PLUS - Liquid (conventional glass ionomer cement)	3M ESPE	114819
FUJI II LC (resin-modified glass ionomer cement)	GC CORPORATION	0206201
VIDRION Powder (conventional glass ionomer cement)	S.S.WHITE	00C
VIDRION Liquid (conventional glass ionomer cement)	S.S.WHITE	00B
Polyacrylic acid	S.S.WHITE	00R

Table 2. Group distribution according to technique and restorative material used

Groups	n	Sub groups	N	Conditioning	Restorative material
GROUP G I	30	G I 1	10	Polyacrylic acid	KETAC FILL
		G I 2	10	Polyacrylic acid	VIDRION R
		G I 3	10	Polyacrylic acid	FUJI II LC
GROUP G II	30	G II 1	10	Polyacrylic acid	KETAC FILL
		G II 2	10	Polyacrylic acid	VIDRION R
		G II 3	10	Polyacrylic acid	FUJI II LC

All cavities were conditioned with 11.5% polyacrylic acid (Dentin Conditioner – SS WHITE, Rio de Janeiro, RJ, Brazil) for 20 seconds, rinsed for 15 seconds and completely dried[6]. The ionomeric materials were proportioned and manipulated according to the manufacturer's instructions and inserted in the cavities with the aid of a Centrix syringe (C-R®.Syringe Centrix™ Speed Slot).

In the subgroups using the glass ionomers KETAC-FILL and VIDRION R, a clear nail polish layer was applied to protect the surface 5 minutes after filling the cavity. Then, 15 minutes later, the teeth were immersed in distilled water for 24 hours. In the subgroups using the glass ionomer FUJI II LC, the material was polymerized for 40 seconds with the light curing unit Ultralux EL (Dabi Atlante, Ribeirão Preto SP, Brazil) at 450 mW/cm² potency and, subsequently, immersed in distilled water for 24 hours.

Afterwards, the teeth were decalcified in a solution containing equal portions of 50% formic acid and 20% sodium citrate changed every 5 days. The complete decalcification of each specimen was radiographically checked. This process completely removes the dental enamel and just maintains the demineralized dentin tissue, which was the subject of this study. After decalcification, the restorations were carefully removed for paraffin embedment.

The specimens were serially sectioned in longitudinal direction through the crown with 6µm in thickness and sequentially mounted in glass slides. Fifteen slides of each specimen containing approximately six sections were selected by systematic sampling with an interval proportional to the number of sections obtained for each specimen. These sections were stained with Brown and Brenn[15] staining technique. Then, the better histological section of each slide was analyzed on a light microscope Axiophot (ZEISS DSM-940 A, Oberkochen, Germany) under 400x of magnification with a micrometric ocular 40/075.

The interface of each section was carefully analyzed in the entire extension of the histological section by a single calibrated examiner.

When an interaction layer between the ionomeric restorative material and dentin was detected, it was measured using a micrometric ocular 40/075 under 400X of magnification. Representative samples of each group were photographed with a film speed ASA 100.

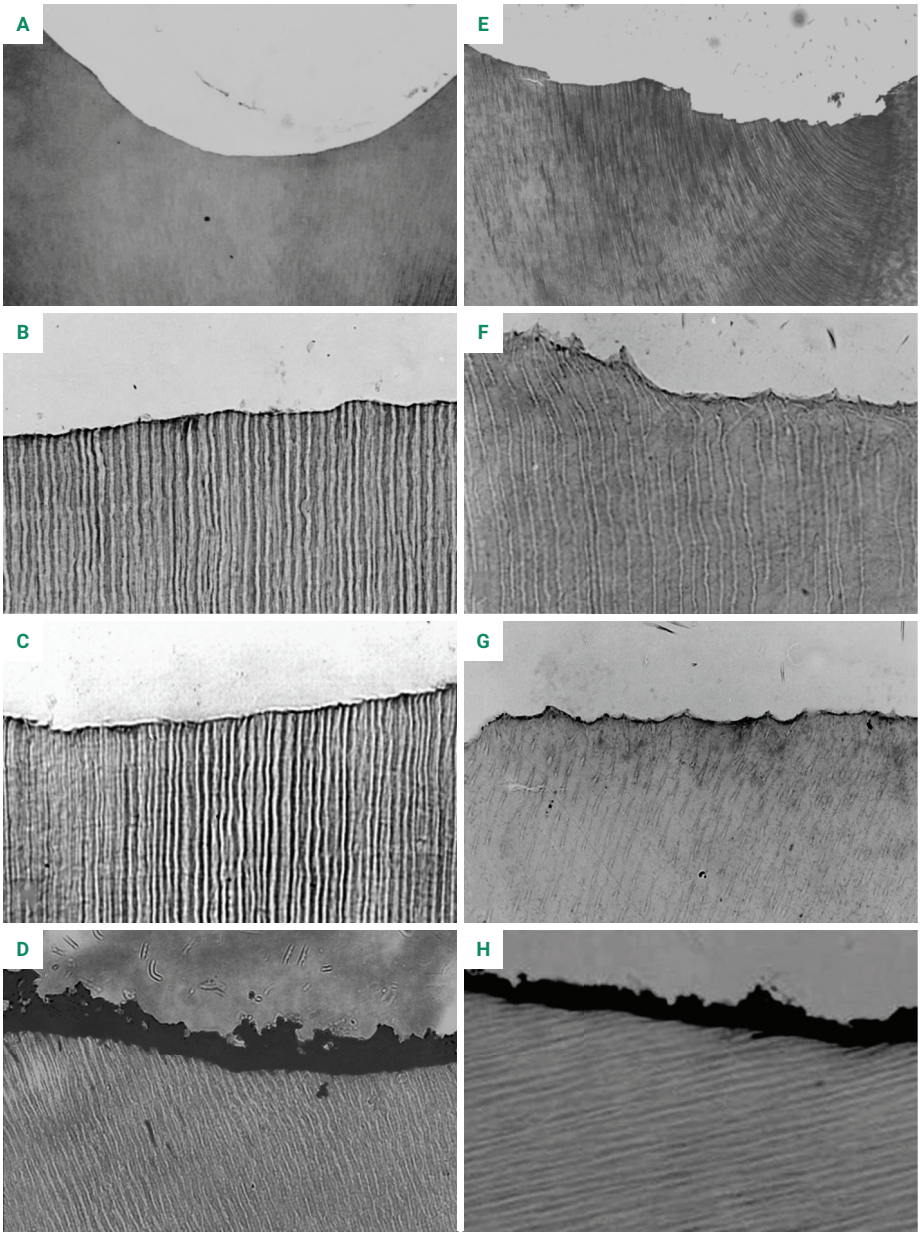

Figure 1. (A) Preparation accomplished with the convention technique in Group GI – Regular dentin surface obtained by the spherical drill (Microscopy 200X). (E) Preparation accomplished with the ART technique in Group GI – Irregular dentin surface obtained by the instruments used in the ART technique (Microscopy 200X). Dentin adhesive surface using the glass ionomer KETAC FILL, VIDRION R and FUJI II LC after carious tissue removal by the conventional technique in B, C and D, respectively (Microscopy 400X). Dentin adhesive surface using the glass ionomer KETAC FILL, VIDRION R and FUJI II LC after carious tissue removal by the ART technique in F, G and H (Microscopy 400X).

Results

Regarding the preparation, the uniformity obtained with the spherical drill used in low rotation was observed for the Group I (Figure 1A). However, the cavity floor surface presented irregular shape in the Group II (Figure 1E).

An absence of ionomeric restorative material on the dentin adhesive surface was noted in the specimens of the groups GI-1(Figure 1B), GI-2 (Figure 1C), GII-1 (Figure 1F) and GII-2 (Figure 1G).

The glass ionomer cement and a stained area were observed on the remaining dentin surface in the Groups GI-3 (Figure 1D) and GII-3 (Figure 1H). This indicates the infiltration of the product into the dentin surface, which means a very significant glass ionomer and dentin interaction. The mean thickness was 7.5µm for the Group GI-3 (Figure 1D) and 2.5µm for the Group GII-3 (Figure 8). All sections exhibited the same pattern (Table 3).

Table 3. Average measurements of the interaction layer between the glass ionomer cement and dentine, according to each treatment group

Groups	GI 1	GII 1	GI 2	GII 2	GI 3	GII 3
N	10	10	10	10	10	10
Averages	0 µm	0 µm	0 µm	0 µm	7.5 µm	2.5 µm

Considering that no variability was observed for the means between the groups GI-3 and GII-3, no statistical analysis was applied. However, it was evident that 7.5µm in thickness represents a better hybrid layer than 2.5µm.

Discussion

In this study, the groups submitted to the conventional technique presented smoother and more uniform dentin surfaces than those submitted to the ART technique, which presented very irregular dentin surfaces.

The ART could be an important treatment method to children, especially those that have high treatment needs, hard access to dental care and limited financial resources. Moreover, this technique can be performed in faster clinical sessions and with reduced cost of treatment being recommended by the International Dental Federation and World Health Organization in worldwide[16]. Researches showed that the longevity of ART restorations in primary teeth are similar from those produced using traditional methods using either amalgam or resin composite[17,18].

Frencken et al.[19] related that an effective method to remove decayed dentine is by using a sharp metal hand excavator, because the rotating metal dental drill may promote exacerbated removal of dental tissue in the prepare the cavity. Indeed, there are studies that reinforce the effectiveness of ART technique in treatment of carious lesion[20].

According to this study, the quality of cavity preparation with the conventional technique for removal of carious dentin tissue could result in a better condition for glass ionomer

and dentin interaction[10]. The regular and uniform preparation favors the material flowage and improves the intimate contact between the material and dentin tissue, which is very important for ionic changes between the glass ionomer and dentin[5,7]. Dentin quality improves glass ionomer adhesion since it is more complete and with greater amount of calcium. This characteristic results in greater amount of carboxyl groups interacting with hydroxyapatite calcium and, thus, a greater adhesive resistance[7].

Although these considerations, it was not possible to maintain the bonding of the conventional glass ionomers KETAC FILL and VIDRION R to dentin submitted to the demineralization procedure. Destruction of the acid-resistant layer during the preparation of the specimens is recommended by some authors which allowed the restoration dislodgment in the cavities without any additional force. However, the use of the resin-modified glass ionomer cement FUJI II LC revealed the interaction layer with dentin. This layer was thicker (7.5µm) when the conventional technique was used for removal of carious dentin in comparison to the ART technique (2.5µm).

Although the interaction layer obtained with the ART technique was thinner, it could characterize an appropriate strong interaction for a long-term adhesive maintenance[11]. Therefore, it will not affect the maintenance of infected dentin when the glass ionomer FUJI II LC is used in the restorative procedure. Bond strength testing should be performed to test this hypothesis.

These results demonstrate that the technique for carious dentin removal does not affect the interaction between the conventional glass ionomers and dentin since the acid-resistant layer was eliminated for both techniques. Nevertheless, a different result was observed when the glass ionomer cement FUJI II LC was used, revealing that dentin quality was important for its interaction with the material. So, it seems that the ionomeric material properties are decisive for the interaction with a sound or demineralized dentin.

However, independent of the technique used for caries removal, the use of cariostatic restorative materials allows the arrest of the carious lesion progress and remineralization of the remaining affected dentin[4,10]. For Maltz et al.[10], the success of this technique certainly depends on the complete cavity sealing, which could be obtained using a glass ionomer due to its adhesiveness and great potential for fluoride release.

Glass ionomer cements present a great remineralizing potential generally associated with mineral deposition in dentin tubules even for a carious dentin[4,21,22]. This property could be a factor for increasing tissue resistance and limiting the action of acidic biofilms[4,10]. This study demonstrated that dentin and glass ionomer cements exchanged minerals and organic elements, forming an intermediate layer. This layer was characterized as an acid-resistant adhesive layer that was not dissolved even under critical demineralization conditions[23,24]. Although studies report the layer formation[9], these observations were partially confirmed in the present study, since the dentin layer incorporated by the ionomeric material was not observed when the conventional glass ionomers KETAC FILL and VIDRION R were used with both techniques. However, when the resin-modified glass ionomer cement FUJI II LC was used, a highly evident interaction layer between the material and dentin was demonstrated. This condition may result from the presence of the hydrophilic resinous components on the

materials composition[24]. Such components generate the acid-resistant adhesive layer and also a micro-mechanical union more resistant to demineralization conditions than the adhesive layer[23]. This established greater retention of the material to dentin, independent of the method for carious tissue removal. According to the methodology used, an interaction between the conventional glass ionomers KETAC FILL and VIDRION R and the dental structure more vulnerable to demineralization conditions was demonstrated in comparison to the resin-modified glass ionomer cement Fuji II LC. VIDRION R and KETAC FILL spontaneously debonded from the cavities with both techniques, especially during decalcification. However, Fuji II LC did not debond from the cavity after decalcification, requiring additional force for its removal. So, this study demonstrated advantage on using resin-modified ionomer cement in comparison to conventional cements considering the cariogenic challenges frequently observed in dental elements. Studies showed that ART using high-viscosity glass-ionomer can be safely and reliably performed in single-surface cavities in both primary and permanent posterior teeth[25].

Therefore, it is important to evaluate the cost-benefit of the ionomeric restorative material used in dental programs for destitute communities. When the ART technique is used, it would be ideal to use resinous ionomer cements for restorations.

It was concluded that the technique used for carious dentin removal does not seem to be determinant for the bonding of ionomeric materials to the dental structure, except for the resin-modified GIC in which the formed hybrid layer was higher using the conventional technique.

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