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IN VITRO EVALUATION OF THE MARGINAL SEAL OF FOUR RESTORATION MATERIALS ON DECIDUOUS MOLARS.

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MOTS CLES: scellé marginal, microinfiltration, molaires de lait, pénétration du colorant, matériaux dentaires.

RESUME

Le but de cette étude était de comparer la qualité du joint marginal de certains matériaux dentaires [Fuji II LC (A), résine composite Z250 (B), Fuji IX GP(C) et Dyract AP (F)] au niveau des cavités de classe V des dents lactéales mais également au niveau de l'interface Fuji IX GP/composite Z250 (D) et Fuji II LC / composite Z250(E) dans le cadre d'une technique sandwich ouverte.

Après thermocyclage, la pénétration moyenne de colorant au niveau de l'émail était respectivement de : 21,6µm ± 14,2 (A), 83,6 µm ± 32,3 (B), 7,5µm ± 7,5 (C), 38,7µm ±27,5

(D) et 0µm (E) et (F) ; et au niveau du cément : 37,1µm ± 20,2 (A) , 123 µm ± 42,1(B), 28,7µm ± 17,1 (C) , 0(D), 14,4µm ±14,4(E) et 0(F) ;au niveau de l'interface Fuji II LC /Z250 ,0µm et 184µm au niveau de l'interface Fuji IX /Z250.

Au niveau de l'émail, la meilleure étanchéité est obtenue avec le Dyract AP (P=0,07) et la moins intéressante avec le composite Z250 (P=0,03 versus Fuji II LC ; P=0,06 versus Fuji IX GP et P=0,03 versus Dyract AP).

Au niveau du cément, la différence d'étanchéité entre le groupe Z250/Fuji II LC versus le groupe Fuji IX GP/Dyract AP était hautement significative (P<0,001), mais il n'y avait pas de différence significative entre le composite Z250 et le Fuji II LC.

ABSTRACT

The aim of this study was to compare the marginal microleakage of Fuji II LC (A), composite resin Z250 (B), Fuji IX GP (C), and Dyract AP (F) in class V cavities and at the Fuji II LC/Z250 (D) and Fuji IX GP/composite resin Z250 (E) interfaces of an open sandwich technique on deciduous teeth.

After thermocycling the mean marginal dye penetration at the enamel junction was 21.6 µm ± 14.2 for group A; 83.6 µm ± 32.3 for group B; 7.5 µm ± 7.5 for group C; 38.7 µm ± 27.5 for group D, and 0 µm for groups E and F. Mean dye penetration at the cementum junction was 37.1 ± 20.2 (A); 123 ± 42.1 (B); 28.7 ± 17.1 (C); 0 (D); 14.4 ± 14.4 (E); and 0 (F) µm.

No leakage was seen at the junction between Fuji II LC and Z250 (0µm), whereas a mean leakage of 184 µm between Fuji IX and Z250 was measured.

In enamel the best seal was obtained with Dyract AP, but with differences at the limit of significance (P=0. 07). Sealing was significantly worse with Z250 (p=0.03 versus Fuji II LC; p=0.006 versus Fuji IX GP; and p=0.003 versus Dyract AP). In cementum, the comparison between the grouped data Z250-Fuji II LC versus Fuji IX GP- Dyract AP was highly significant (p<0.001), while there was no detectable difference between Z250 and Fuji II LC

INTRODUCTION

The filling of cavities in deciduous teeth remains a clinical trial, most adhesive materials such as composite requiring a very accurate technique (Miyazaki M et al 1998) in order to obtain adhesion values similar to the in vitro measures. These conditions, including the use of a rubber dam, are not always met in small and sometimes uncooperative children, and the in vitro studies, mostly performed on bovine or human adult dental tissue rarely reflect the clinical behaviour of a material, especially in pediatric dentistry.

Other materials, less technique-sensitive, are used, such as glass ionomers, and are useful in selected clinical situations based on the slow fluoride release and subsequent cariostatic potential but also the chemical bonding to enamel and dentin, providing a tight interface and reducing the need for retentive cavity preparation (Garcia-Godoy F *et al* 1986, Lin A *et al* 1992, Mc Caghren R.A. *et al* 1990 and Christensen R.P. *et al* 1998). However, the mechanical properties of the first glass ionomer were poor. The light-hardening glass ionomer cements that were introduced in the early 1990s improved the ionomers' mechanical properties, especially wear resistance and fracture toughness (Croll T.P. *et al* 1993, Hegarty A.M. *et al* 1993, Mitra S.B. *et al* 1994).

Lately, other light curing materials called compomers and composed mainly of composite resin have shown better physical properties than those of light-hardened glass ionomer cements. They combine the major benefits of glass ionomer cements, *i.e.*, adhesion to tooth structure, fluoride release, biocompatibility, but also of composites, *i.e.*, esthetic and mechanical properties, quality of the marginal seal (Morabito A *et al* 1997). Cavity preparation may be kept to the minimum required for caries removal, as preparation of mechanical retention is not needed unless the restoration is liable to be subjected to high displacement forces.

Secondary caries due to microleakage are the most frequent indication for removing resin-based composite restorations (Burke F.J. *et al* 1999, Kohler B *et al* 2000), although it is difficult to differentiate clinically between secondary caries and marginal discoloration (Kidd E.A. *et al* 1996, Mjor I.A. 1998).

The chemical bonding of glass ionomers is supposed to provide a tight seal between the tooth structure and the material, leading to the so-called "sandwich technique" where a deep layer of glass ionomer is partially or totally covered with a composite layer, with better mechanical properties.

Efforts have also been made to develop new monomers and improve resin-dentin or even resin-cement bond strengths (Lopes G.C. *et al* 2002, Toledano M *et al* 2001) but up to now none of the existing materials have met all the demands in clinical testing.

The aim of this study was to test the quality of the marginal seal of class V carious lesions in primary molars in an *in vitro* physiological model using a light-cured glass ionomer cement, compomer, composite, and traditional glass ionomer cement.

MATERIAL AND METHODS

Deciduous teeth extracted for pulp disease or for orthodontic reasons were examined.

The teeth utilized in this study were obtained accordingly to the protocol (06/2002) analyzed and approved by the Ethical Committee in Research, Reine Fabiola Hospital, and with the informed consent of donors.

Teeth were rejected when carious decay extended to the cavity preparation and the remaining teeth stored in a physiological solution.

Two standardized mixed class V cavities ((l) (w)(h) = 4 mm x 2 mm x 2 mm) were drilled in the buccal and lingual surfaces, of each tooth with a coarse diamond bur (CF980.204.035, Komet, Lemgo, Germany), with the occlusal limit in the enamel tissue and the gingival limit in the cement in order to assess the marginal leakage at both the cement-material and enamel-material seals.

The 132 prepared teeth were assigned randomly to six experimental groups of 22 teeth each, corresponding to the different restorative systems. The manufacturer's instructions were followed strictly for each material.

In the first group (A), the cavities were filled using Fuji II LC (GC Corporate, Tokyo, Japan), *i.e.*, a light-cured reinforced glass ionomer restorative. The cavities in the second group (B) were filled using composite restorative Z250 (Filtek™ Z250, 3M Dental Products, St Paul, MN, USA). The etching was performed for 15 seconds with a 37% phosphoric acid solution, and the Scotch Bond™ adhesive system was used according to the manufacturer's instructions. The cavities in the third group(C) were filled using Fuji IX (Fuji IX GP, GC Corporate, Tokyo, Japan), a self-curing glass ionomer cement, after application of a dentin conditioner(GC Corporate, Tokyo, Japan) for 15 seconds. In the fourth group(D), an open sandwich technique was used, with a first layer of Fuji II LC covered with a second composite layer (Filtek™ Z250 3M Dental Products, St Paul, MN, USA), excepted at the margins of the preparation. In the fifth group (E) an open sandwich technique involving a first layer of Fuji IX GP overlaid with a Z250 layer, except at the margins, was used. The cavities in the sixth group (F) were filled using Dyract AP, a compomer restorative material (Dyract AP, Dentsply, Detrey Konstanz, Germany), using the Prime and Bond® NT and NRC™ adhesive system following the manufacturer's instructions. (Tab. 1)

All the teeth were thermocycled 5000 times between 5 and 55°C, keeping them in each bath for 30 seconds. After thermocycling, the teeth were covered with two coats of fingernail polish up to approximately 1 mm of the restoration margin and immersed in 2% methylene blue for 24 hr. After removal from the dye solution the teeth were cleaned, rinsed with tap water, and sectioned longitudinally through the centers of the restorations.

Tab. 1: Restorative materials used in the dye-penetration study on class V cavity.

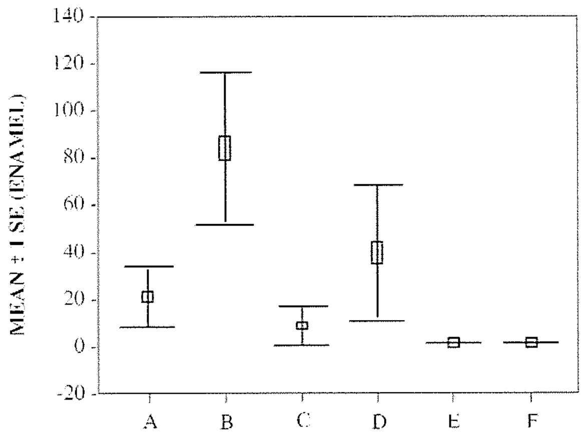
GROUP	MATERIAL	MANUFACTURER
A	GC Fuji II LC	GC Corporate, Tokyo, Japan
B	Composite resin Z250	3M Dental Products, St. Paul, MN, USA
C	GC Fuji IX GP	GC Corporate, Tokyo, Japan
D	GC Fuji II LC+Z250	GC Corporate, Tokyo, Japan 3M Dental Products, St. Paul, MN, USA
E	GC FUJI IX GC GP+Composite resin Z250	Corporate, Tokyo, Japan 3M Dental Products, St. Paul, MN, USA
F	Dyract AP	Dentsply, Detrey Konstanz, Germany

The different samples were examined under a stereomicroscope (Catima program, Deltalogic) to analyze dye penetration at the marginal seal of each restoration

RESULTS

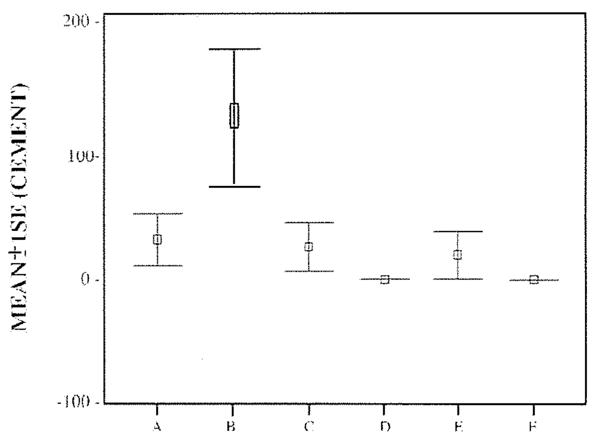
At the enamel junction, the results (expressed as mean ± SE dye penetration in µm) were as follows: group A (Fuji II): 21.6 ± 14.2; B (Z250): 83.6 ± 32.3; C (Fuji IX): 7.5 ± 7.5; D (Fuji IX + Z250): 38.7 ± 27.5; E (Fuji II + Z250): and 0; F (Dyract): 0. The percentage of perfect seals for each material was 93, 75, 97, 93, 100, and 100 percent for A, B, C, D, E, and F, respectively. These data are expressed in Table 2.

Tab. 2: Mean in depth dye-penetration and standard error of means at the enamel margin.



At the cementum junction, the results (expressed as mean ± SE dye penetration in µm) were as follows: group A: 37.1 ± 20.2; group B: 123 ± 42.1; C 28.7 ± 17.1; D: 0; E: 14.4 ± 14.4; F: 0. The percentage of perfect seals for each material was 85, 72, 92, 100, 96, and 100 percent for A, B, C, D, E, and F, respectively. (Tab. 3)

Tab. 3: Mean in depth dye-penetration and standard error of means at the cementum margin.



Statistical analysis

The distributions of dye penetration were compared using nonparametric tests.

Enamel: When the data are analyzed as **continuous variables**, the best seal is obtained with material F, followed by C and A. Material B is in last position. The observed differences in the average values reflect theoretical differences in the materials, since the Kruskal-Wallis test comparing the six distributions is highly significant ($p = 0.001$). If material B is excluded, no significant difference between the five remaining materials ($p = 0.34$) is found. When compared by pairs, material B is significantly different from materials A ($p = 0.02$), C ($p = 0.005$), E ($p = 0.005$), and F ($p = 0.004$). When the data are analyzed as **dichotomized variables**, the best seal is obtained with material F, followed by C and A. Material B is in last position. These differences, which are seen in the average values, reflect theoretical differences in the materials, since the square test of heterogeneity comparing the six distributions is highly significant ($p < 0.001$). If material B is excluded, no significant difference between the five remaining materials is found ($p = 0.34$). When compared by pairs, material B has a significant difference from materials A ($p = 0.03$), C ($p = 0.006$), and F ($p = 0.003$). The analysis allows us to conclude that material B has statistically more leakage than the five other materials, without it being possible to detect any theoretical differences between any of these five materials.

Cementum: When the data are analyzed as **continuous variables**, the best seal is obtained with material F, followed by C, A and B. The differences seen in the average values reflect theoretical differences in the materials, since the Kruskal-Wallis test comparing the six distributions is highly significant ($p = 0.001$). If material B is excluded, heterogeneity is at the limit of significance ($p = 0.07$). When material A is withdrawn from the comparison no significant difference is found among the four remaining materials. The comparison between the grouped data A-B versus C-F is highly significant ($p < 0.001$), while there is no detectable difference between A and B ($p = 0.11$). When the data are analyzed as **dichotomized variables**, the best seal is obtained with material F, followed by C, A, and B. The observed differences reflect theoretical differences in the materials, since the square test of heterogeneity comparing the six distributions is highly significant ($p = 0.001$). If material B is excluded, the heterogeneity remains at the limit of significance ($p = 0.07$). If material A is also withdrawn from the comparison no significant difference between any of the four remaining materials can be found ($p = 0.26$). The comparison between the grouped data A-B versus C-F is highly significant ($p<0.001$), whereas there is no detectable difference between A and B. These data allow us to conclude that materials A and B have significantly more leakage than materials C and F, without it being possible to detect a theoretical difference between C and F ($p = 0.17$).

The mean dye penetration at the junction between the two layers was 183.9 ± 78.4 for the Fuji IX-Z250 interface and 0 for the Fuji II-Z250 interface, with respectively 67% and 100% perfect seals. From the standpoint of adhesion, Fuji II appears to be a better choice than Fuji IX for use in an open sandwich technique.

DISCUSSION

A major objective in restorative dentistry is the control of marginal leakage, which may occur because of dimensional changes or a lack of adaptation of the restorative material to the cavity preparation, leading to recurrent caries and pulp disease. Several methods, including radioisotopes, dyes, air pressure, bacterial penetration, pH changes and scanning electron microscopy, have been introduced in order to assess this microleakage, but the observation of dye penetration is the most common.

If we compare leaking at the enamel junction by pairs (composite Z250 with each of the other materials), we find a significant difference with Fuji II LC ($p = 0.02$), Fuji IX ($p = 0.005$), and Dyract AP ($p = 0.005$). At the cement margin the comparison between the grouped data of composite versus Fuji IX and Dyract AP is highly significant ($p < 0.001$), while there is no detectable difference between Z250 and Fuji II LC ($p = 0.11$). Thus, Z 250 bonds less tightly to cement than Fuji IX and the compomer, whereas better results might have been expected for Fuji IX and Fuji II LC versus Dyract, because they contain glass ionomers, which are famous for their chemical adherence to cement.

The adhesive dental materials used in pediatric dentistry are mainly composite resins, glass ionomer cements, hybrid glass ionomer cements, and polyacid resin modified composite materials. Sandwich techniques associating several of these materials, *e.g.*, restoration laminated in glass ionomer/composite resin, are also used. Composite resins have excellent mechanical properties, including wear resistance and fracture resistance, and are thus indicated even for class I and II restorations. However, their major disadvantages for the restoration of temporary teeth are the need for perfect handling and rigorous control of the operative field. Moreover, this study indicates that Z250 does not induce a good seal on either enamel or cementum.

Traditional self-hardening glass ionomers gained only mild acceptance in pediatric dentistry for several reasons, namely, long hardening times, sensitivity to over-hydration or desiccation, and poor wear and fracture resistance. However, modification of the size and the distribution of the glass particles in Fuji IX GP, allowing a faster reaction and enhancing its physical properties, has reduced the hardened cement's sensitivity to moisture and solubility in oral fluids. This cement is used by many practitioners for restorations of deciduous teeth. (Berg JH 1998, Mount GJ 1999, Nicholson JW *et al* 1997). The results of this study indicate that Fuji IX GP provides a good seal on both enamel and cementum.

Filling materials made of resin modified glass ionomers were proposed in the 1990s. These materials contain a light-curing resin component but also harden by the acid-base reaction that is typical of glass ionomers. Their advantages over glass ionomer cements are the speed of the initial photopolymerization and enhanced fracture strength and hardness (Croll TP *et al* 1993, Quackenbush BM *et al* 1998) . Moreover, they are more esthetic and have been used successfully to replace tooth structure in the deciduous dentition.(Nicholson JW *et al* 1997, Croll TP *et al* 1993). This study indicates that Fuji II LC behaves similarly to Fuji IX GP when it comes to marginal sealing on enamel and cementum, but has better adhesion to composite.

A significant property of glass ionomers, including hybrid glass ionomers, is their ability to release fluorides, which can be taken up by enamel and dentin (Christensen RP *et al* 1998, Donly KJ 1994, Donly KJ *et al* 1994, Ewoldsen N *et al* 1998, Segura A *et al* 1997).

Since Mc Lean and Wilson described the sandwich technique (Mc Lean JW *et al* 1985, Mc Lean JW *et al* 1997), the concept of replacing the dentin mass with glass ionomer cements and the enamel with composite resin has been used in pediatric dentistry. Dentin and enamel are radically different tissues with different biological properties. Postoperative sensitivity has been reported when composite resins are placed directly on etched dentin, but not with a glass ionomer base. (Mc Lean JW *et al* 1985)

The idea of biomimetism achieved by replacing dentin and enamel with separate materials stuck to each other has the disadvantage of involving a lengthier procedure, but the eventual therapeutic benefit for the patient must remain the essential objective. In this study, an open sandwich technique consisting of a glass ionomer cement layer (either Fuji II LC, or Fuji IX) partially covered with composite resin was used. One of advantages of using an open sandwich technique to treat class II cavities is the contact of glass ionomer cement and saliva allowing a fluoride release and thus a reduced incidence of secondary caries. The occlusal part of the restoration subjected to the occlusal mastication strengths is covered by composite resin with better mechanical properties. Moreover, the seal achieved by Z250 was significantly worse than the other materials that were studied. This is one more argument in favor of an open sandwich technique, since sealing with the glass ionomer was significantly better. The leaking at both the enamel and the cementum junctions is comparable for Fuji II LC and Fuji IX GP, but the seal between Fuji II LC and Z250 is better than the seal between Fuji IX GP and Z250. Resin modified glass ionomers thus seem a better choice for the deep layer of an open sandwich technique in the deciduous dentition.

CONCLUSIONS

Fuji IX GP behaved similarly to a resin modified glass ionomer (Fuji II LC GC) and a compomer (Dyract AP) in producing a marginal seal. Since Fuji IX can be used under minimal conditions, this is a promising result for a material targeted for application in conjunction with the Atraumatic Restorative Technique (Motsei S.M. *et al* 2001, Castro A. *et al* 2002, Louw A.J. *et al* 2002, Rahimtoola S. et al 2002, or minimal intervention treatment in pediatric dentistry, even though further investigation will be needed in order to assess the quality of sealing under more "atraumatic" caries removal conditions.

On the other hand, Dyract AP has good mechanical properties, produces an excellent marginal seal, comes in a wide choice of colors, has a combined preventive action due to fluoride release, and is a good choice for restorations in children. The best open sandwich technique seems to consist of a deep layer of modified glass ionomer partially covered with a composite resin.

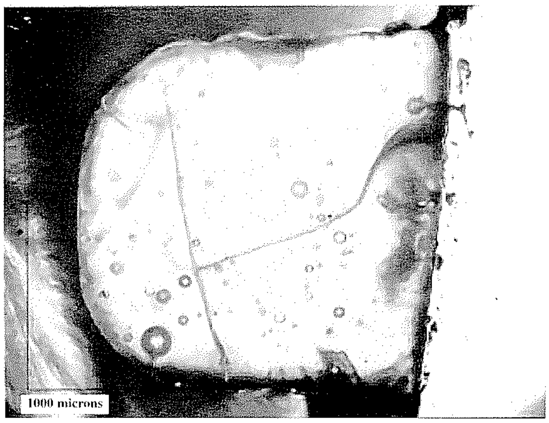


Fig. 1: At 100X magnification a specimen filled with a GC Fuji II LC shows slight dye penetration..

Fig. 2: At 100X magnification one specimen filled with Dyract AP shows no dye penetration.

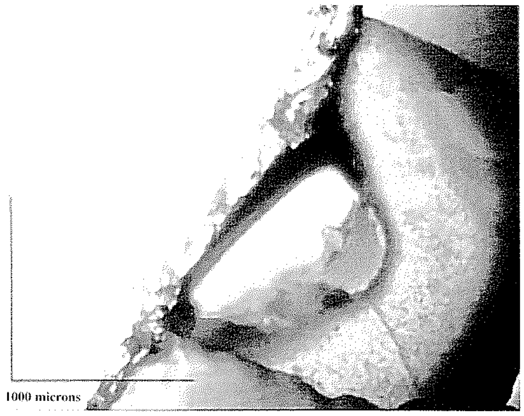


Fig. 3: At 100X magnification a tooth filled by means of an open sandwich technique (GC Fuji IX GP + composite Z250), shows no dye penetration along the walls of the cavity and very superficial dye penetration along the Fuji IX-composite Z250 interface

Fig. 4: At 250X magnification a tooth filled with a composite resin Z250 shows deep dye penetration along the cavity's walls.

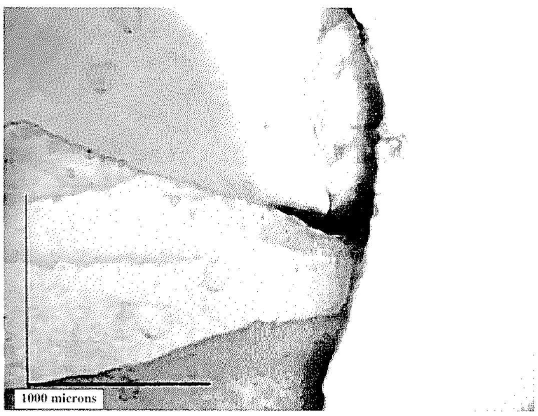


Fig. 5: At 100X magnification a tooth filled with GC Fuji IX GP shows slight infiltration into the cavity's walls.

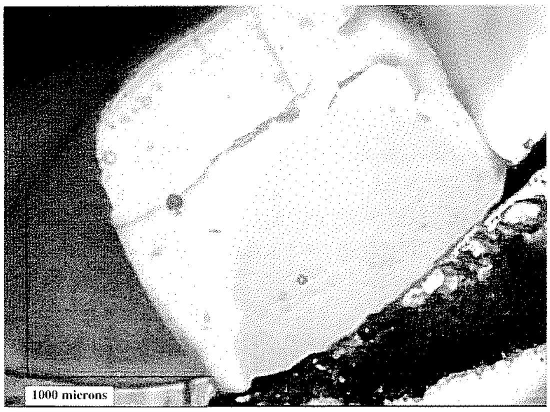


Fig. 6: At 100X magnification a tooth filled by means of an open sandwich technique (GC Fuji II LC + composite resin Z250) shows no dye penetration.

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