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The Effect of the Compomer Filling Material on Adjacent Demineralization Lesion: An *In Vitro* Study

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Abstract. This study evaluated the effect of Compoglass restorative material placed in class-II restoration on the adjacent sound enamel. 120 extracted human impacted third molars were divided into 4 groups: Compoglass, Glass Ionomer Cement, Z250 and Control. Each group contained 15 paired teeth. Class-II preparation was performed on one tooth of each pair, and restored. Teeth were placed in demineralization solution for three weeks. The proximal surface of un-restored teeth were sectioned longitudinally (140-160μm) and analyzed microradiographically. Chi-square showed significant differences among all groups, (df = 3 = 10.01, p = 0.018). Pair-wise comparisons showed that: Compoglass had less demineralization than the control (df = 1 = 4.8, p = 0.033) and was no different from GIC (df = 1 = 0.2, p = 0.5). Copmoglass had less demineralization than Z250, however, not significant (df = 1 = 3.4, p = 0.07). There were significant differences between GIC and Z250 (df = 1 = 5.0, p = 0.03) and the control (df = 1 = 6.6, p = 0.013). Z250 was no different from the control (df = 1 = 0.14, p = 0.5). The study demonstrates the ability of Compoglass to intervene before a carious lesion occurs when placed in an adjacent class-II restoration.

Keywords: Compoglass, Z250, Glass ionomer cement, Demineralization, Class II restoration, Proximal contacts.

Introduction

The clinical study focuses on dentistry which has evolved over the past century, from merely providing restorations for carious lesions to early detection of incipient carious lesions and prevention of caries.

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Dental decay is the result of an imbalance between the process of demineralization and that of remineralization. One of the main problems of odontology remains in the increase of mineralization in the dental enamel in the post-eruptive maturation stage, and the remineralization of the incipient dental decay lesions. Today, the concept of dental practice involves the prevention of enamel demineralization and promotion of enamel remineralization; consequently directed toward the interception of the disease process and restoration of the affected host.

Early carious lesions are difficult to detect, especially at the interproximal surface, clinically or radiographically, until the lesion progresses to cavitate enamel where demineralization has become irreversible. Therefore, with the goal of restorative dentistry directed towards prevention of future diseases, restorative materials and preventive measures in the patients' population have undergone a major improvement. In the last decade, composite resins and glass ionomer cements (GIC) have increased in use as a restorative dental material.

More recently, composite resin has been formulated with the ability to release fluoride[1,2]. The ability of a restorative material to reverse and inhibit caries formation is an important clinical property. The fluoride released from restorative materials such as glass ionomer can play a role in caries prevention and remineralization of early carious lesion according to *in vivo* and *in vitro* studies[3-13]. This has paved the way to the introduction of a new class of dental materials, the term “Compomers”. Compomer, which combine the benefits of composite and glass ionomer; is a class of dental materials that have an excellent properties, including the natural release of fluoride[14]. While many *in vitro* studies have investigated the ability of GIC with fluoride to reverse caries produced in an artificial caries solution, no studies to date have investigated the similar use of compomer.

Compomers have been introduced as a class of dental materials. These materials provide the combined benefits of composites (the “comp” in its name) and glass ionomers (“omer”). Compomers have two main constituents: dimethacrylate monomers with two carboxylic groups present in their structure, and filler that is similar to the ion-leachable glass present in glass ionomers[14].

Unlike fluoridated toothpaste and mouth rinse utilization, fluoride in a restorative material, is always available for release, which is not dependant on patient compliance.

The aim of the current study is to demonstrate that Compomers can prevent a caries lesion from occurring in a sound tooth adjacent to one filled with Compomer with its fluoride realizing property.

Materials and Methods

One hundred twenty extracted human impacted third molars were selected for the study. The teeth were cleaned, rinsed in water and stored in water with 0.1% Thymol solution (for disinfection) until the beginning of the study to prevent dehydration. Teeth with the following criteria in the enamel surface were excluded:

a. Caries.
b. Cracks.
c. Hypocalcification.
d. Hypoplasias.

The teeth were randomly divided into four groups with 30 teeth in each group as follows:

1. <u>Group I: Experimental</u> (n=30): 15 teeth with Class II Compoglass restoration (Ivoclar Vivadent Inc. Amherst, N.Y, USA) and 15 sound teeth.
2. <u>Group II: Positive control</u> (n=30): 15 teeth with Class II Glass Ionomer Cement restoration (Vitremer 3M Dental Products, St. Paul, MN) and 15 sound teeth.
3. <u>Group III: Negative control</u> (n=30): 15 teeth with Class II Z250 composite resin restoration (3M Dental Product, St. Paul, MN) and 15 sound teeth.
4. <u>Group IV: Control</u> (n=30): 30 teeth with no restorations.

Teeth Preparation

A standard cavity preparation 3 mm in diameter and 4 mm in depth were prepared in the middle third of mesial proximal surfaces of 45 teeth (15 from each restoration groups). Each tooth was varnished with a nail varnish (Nails Inc, London) on all surfaces, except 1 mm around the restoration. Also, the un-restored adjacent teeth were painted with the same varnish leaving a 5 mm area exposed to the adjacent restoration.

Teeth Mounting

Each of the restored teeth was paired with a sound tooth. Each of these pairs was mounted in an acrylic block, thus stimulating a natural contact area.

Each group consisted of 15 acrylic blocks with one pair each (restored and un-restored teeth).

Teeth Restoration

The teeth were filled with restoration according to the manufacturers' instructions. The restoration materials used are: GIC Vitrabond™ (3M), Compoglass® (Ivoclar) and Filtek™ Z250 (3M).

Demineralization Solution[15]

Each acrylic block underwent 24 hours of demineralization for 3 weeks at 37°C in 40 ml of solution at pH 5 that contains the following:

a) Calcium Chloride 3.2 mmol.
b) Potassium Phosphate 6.7 mmol/L.
c) Lactic Acid 0.065 M.

Determination of Caries Lesion

At the end of 3 weeks, the proximal enamel surface of un-restored tooth was sectioned longitudinally by means of a diamond saw (Silverstone-Taylor Hard Tissue Microtome, Scientific Fabrication, Littleton, CO USA) to obtain thin (160-180 µm) sections of the enamel.

Each section was then reduced in thickness to 140 to 160µm by the use of 600-grit silicon carbide grinding paper (all teeth preparations were made by the same operator). The sections were analyzed microradiographically. Microradiographs of the sections were obtained by means of a Faxitron X-ray system (Hewlett Packard, McMinnville, OR, USA). Hoolographic (SO-253) high-speed film (Kodak, Rochester, NY, USA) was used for this purpose. Exposure time was 10 min at 40 kVand 3 mA. Obtained microradiographs were analyzed by means of a video image analysis system and software. The resolution of the system is limited by the dimension of a pixel, or less than 3 μm^2 to evaluate the presence or absence of a caries lesion. Also, we evaluated the Compoglass restorative filling material in comparison with positive control (glass ionomer) and negative control (Z250 composite, none fluoridated composite).

Results

Statistical analysis was performed using Statistical Program for Social Sciences (SPSS) software, Version 10 (SPSS Inc.).

The sectioned teeth were individually evaluated for presence of demineralization and absence of demineralization. A score of 1 was given to the section that exhibited demineralization and 0 to the section with no demineralization, Table 1 shows the collected data from all the sections. Chi-square test was used and the results showed a statistically significant difference (Table 2).

Table 1. **Number of sectioned teeth in all groups divided into group which showed demineralization and no demineralization n = 15.**

Groups	Demineralization		No demineralization		Total
	No. of teeth	%	No. of teeth	%	
Compoglass	4	26.7	11	73.3	15
GIC	3	20	12	80	15
Z250	9	60	6	40	15
Without restoration	10	66.7	5	33.3	15

Table 2. **Chi-square tests.**

	Value	df	Asymp. sig. (2-sided)
Pearson Chi-Square	10.045	3	0.018

Using the Fisher's exact test, it demonstrated that Compoglass restorative material showed a significant result compared to the no-restoration group, but not a statistically significant different from the GIC and Z250 groups.

The statistical analysis showed that Compoglass prevented the sound tooth in comparison to control group (no restoration) and not a statistically significant to negative control (Z250) p value = 0.033 and = 0.07, respectively.

There were significant differences between GIC group with negative control group (Z250) and no restoration group with regards to the presence or absence of decay p value = 0.030 and 0.13 respectively. There was no significant difference between GIC group and Compoglass group for presence or absence of decay in the sound enamel opposite to the restorative fillings.

For the negative control group, there was no significant difference with control group (no restoration) (Fig. 1).

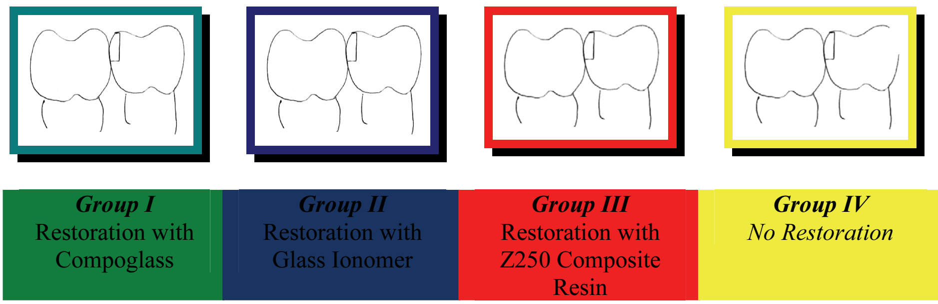

Fig. 1. Diagram illustrating Class II restorations adjacent to a sound tooth.

Discussion

The goal of this study was to determine the *in vitro* effects of Compoglass placed in a class II restoration on the adjacent sound enamel surface from a preventive point of view.

One of the early studies that tested fluoride-releasing composite was performed by Donly and Gomez[1] in 1994. They demonstrated a significant area reduction in the body of the lesion exposed to the fluoridated composite resin at 2-week and 3-month intervals. This group of investigators expanded their research and performed an *in vivo* study to evaluate the effect of fluoride releasing dental materials on adjacent dentition. In 1999[5], they published their work, which comprised of a six-phase, crossover study in order to develop a model system with which to effectively evaluate the demineralization and remineralization effects of fluoride-releasing dental materials. They found that resin-modified glass-ionomer cement significantly inhibits demineralization of the interproximal enamel of teeth, adjacent to those restored with the cement.

Segura *et al.* in 1997[10], compared three types of materials which are GIC/resin composite, GI silver cement and amalgam placed in a class II cavity. They found that GIC/resin composite demonstrated a significant decrease in pore volume, than did both of the other two materials. There was no significant difference between the GIC/resin composite and GI silver cement in pore volume. Furthermore, Marinelli *et al.* 1997[16] compared three fluoride regimens (fluoride rinse, fluoridated dentifrice and fluoride releasing restorative material) on enamel remineralization. The fluoride rinse was found to be most superior in the caries reversal process.

In 2001, Helvatjoglu-Antoniades *et al.*[2], concluded that fluoride release occurred from different types of restorative materials and a luting cement: 4 glass ionomers (Miracle-Mix, Fuji ionomer type III, Fuji II LC improved and ketac-Silver), a luting cement (Ketac-Cem), a compomer (Compoglass Flow), 2 sealants (Fissured F, Helioseal F) and a composite resin (Tetric), over the 16-week testing period. Among the materials tested, fluoride release from the glass ionomer formulations and compomer was greater than that from sealants and composite resin. Interestingly, they found that fluoride released from all the different materials tested was similar and peaked within the first 24 hours.

Carvalho and Cury in 1999[17] conducted a study to determine the level of fluoride released from different restorative materials (Chlon-Fil, Dyract, Variglass, Vitraemer and Tetric) in storage solutions, deionized water, artificial saliva and pH cycling solution. The result data showed that all materials in each medium had the same qualitative fluoride released pattern during the study (15 days). The concentration of fluoride was higher during the first 24 hours, declined sharply on the second day and then gradually diminished to a nearly constant level for each material. The fluoride released was consistently higher in pH cycling solution than in water and lowest value was observed in artificial saliva.

When developing *in vitro* models for testing biological properties of a given dental material, or teeth, which are filled with this material, it must be subjected to a caries simulation process.

One of the first researchers to establish the caries simulation model was Featherstone[15], Featherstone and Mellberg[18]. In 1981, they studied the rate of formation of artificial caries lesions produced and measured independently by two different techniques in bovine, ovine and human deciduous and permanent enamel. It showed a consistent pattern. The lesions progressed approximately one and a half times more rapidly in deciduous bovine and human than in permanent enamel. The rate was faster in bovine permanent enamel as compared to human teeth. Then in 1996, Featherstone[15] reviewed different caries simulation models that were used to assess caries inhibitory properties of dental materials. There were seven models available and each one aims to investigate the usefulness of fluoride on the material that has been tested[15]. Three of the models were *in vitro*, two were *in vivo*, one was *in situ* and the last model was an artificial mouth. They were classified as follows: *In vitro* demineralization using acid buffer; the simplest model in which an acid buffer or an acid buffer with calcium and phosphate was used. Due to the absence of saliva, no remineralization stage occurred, no replenishing of acid and no removal of released components from the test material, therefore the result must be interpreted with caution. Whatever was released from the tested material into the solution, such as fluoride, remains and builds up by time, which confounds the outcome.

In the *in vitro* demineralization system using bacterially generated acids, the tested material was immersed in a medium that contains bacteria such as *S. mutans*. The result must be interpreted with caution for same reason as the first model. A dental material that releases an antibacterial agent is not a useful model. In the *in vitro* demineralization / remineralization system using a pH-cycling system, it has been shown as a good model to assess fluoride releasing dental , however it will not be useful for assessing antibacterial agent. This model simultaneously measures the net result of the inhibition of demineralization and the enhancement of remineralization. Solutions can be renewed regularly; tested materials are immersed in the demineralization solution for several hours then in the remineralization solution for hours. This procedure is then cycled for several days.

The *in vivo* animal model (rat model) is expensive, time consuming and the samples are very small. The saliva of a rat is different from humans and the dynamics are also different, therefore, the result must be interpreted with caution.

In *in vivo* studies using teeth scheduled for extraction, a model was glance, which is closest of all to a human clinical trial. It uses vital teeth, saliva and plaque, which are present along with normal dietary challenges. This model is demanding, time consuming and expensive.

In the *in situ* demineralization and/or remineralization model of the human mouth, in which, blocks or slices of enamel or dentine are placed in appliances in the human mouth for periods of time and assessed for demineralization or remineralization. In this model, dental materials could be tested for fluoride efficacy, antibacterial efficacy.

The last model utilizes an artificial mouth where a bacterially generated acid challenges were interspersed with a saliva treatment.

Under the condition of this study, Compoglass demonstrated the ability to prevent the demineralization of the adjacent enamel when used as a filling material of a class II restoration. The controls (no restoration and Z250) did not prevent the demineralization effects of the demineralization solution and caries lesions occurred in the adjacent enamel. In contrast, both Compoglass and GIC showed prevention effects of carious lesion for the adjacent enamel. Figure 2 illustrates a Class II restoration adjacent to a sound tooth.

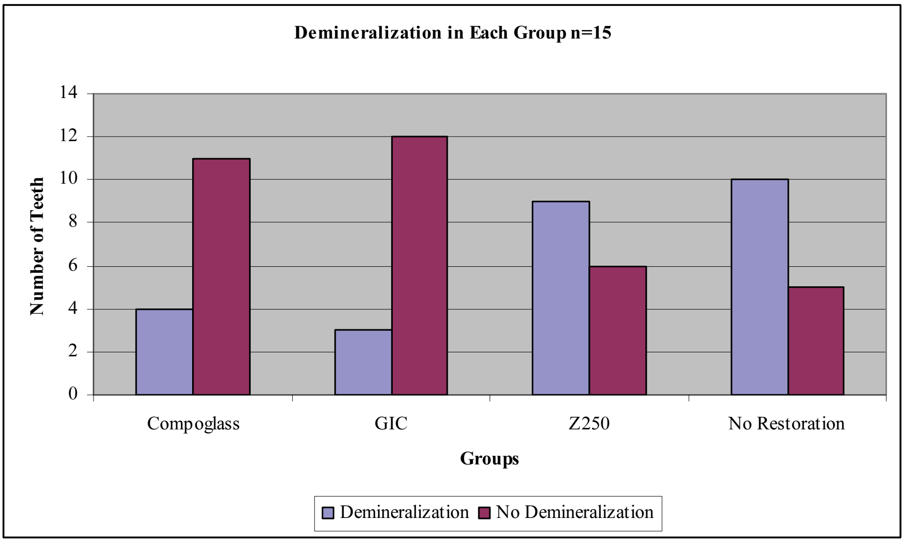

Fig. 2. Number of demineralization and no demineralization in each experimental group.

When GIC was compared to the no restoration group and Z250, a significant effect was found. This was consistent with other studies performed on the fluoride releasing properties of GIC[3,5-7,9-11,13].

The teeth used in this study were whole un-sectioned sound teeth, which were immersed in the demineralization solution, unlike other studies where tested teeth sectioned into thin sectioned before immersing them into the solution. Sectioning the teeth before the demineralization might affect the depth of penetration of the solution into the enamel, thus rendering a more ‘artificial ‘caries production rather than a natural process. It also does not address whether the fluoride restorative material was related to depth of penetration. Whereas, using a sound tooth mimics the natural oral environment.

The significance of this study lies in the fact that, it demonstrates the ability of Compoglass to intervene before a carious lesion occurs when placed in an adjacent class II restoration. Future clinical studies with long-term follow-up are necessary to verify the preventive role that Compoglass plays in the oral environment.

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مقاومة تحلل سطح الأسنان الملاصقة لحشوات الكومبومر

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المستخلص. تهدف هذه الدراسة الى تقييم أثر Compoglass على سطح المينا المجاورة السليمة. مائة وعشرون ضرسا مخلوعا استخدمت في هذه الدراسة وتم تقسيمها إلى ٤ مجموعات متساوية (Compoglass، GIC متحكم ايجابي، Z٢٥٠ متحكم سلبي، ومتحكم عام "بدون حشوات"). كل مجموعة تحتوي على ٣٠ ضرسا مكونة ١٥ زوجا. تم إعداد حفرة سنية (Class II) على ضرس واحد من كل زوج للمجموعات التجريبية وبعد ذلك حشيت كل مجموعة إما بـــ Compoglass أو GIC أو Z٢٥٠. كل المجموعات بما في ذلك مجموعة التحكم العام، وضعت فى محلول مفكك المعادن لمدة ثلاثة أسابيع. وبعد ذلك أخذت الضروس السليمة الملاصقة للضروس المحشية من مجموعاتها وشقت طوليا باستخدام المنشار الماسي إلى شرائح بسماكة ١٦٠-١٤٠ ميكرون. تم دراسة تلك الشرائح تحت المجهر الإلكتروني بصورة تكبيرية ٤٠ ضعفاً. أظهر التحليل الإحصائي وجود اختلافات كبيرة بين المجموعات الأربع، وقد تبين أن السطوح الملاصقة لـــ Compoglass كانت أكثر مقاومة لمحلول التفكك من مجموعة المحكم العام، بينما لم تختلف تلك الأسطح الملاصقة لـــ Compoglass عنها في GIC. الأسطح الملاصقة لـــ

Copmoglass كانت أكثر مقاومة لمحلول التفكك عن الأسطح الملاصقة لحشوات Z٢٥٠ إلا أن هذا الاختلاف لم تبلغ قيمة كبيرة. تكمن أهمية هذه الدراسة في استنباط قدرة مادة الـــ Compoglass على منع تحلل سطح الأسنان الملاصقة لها.